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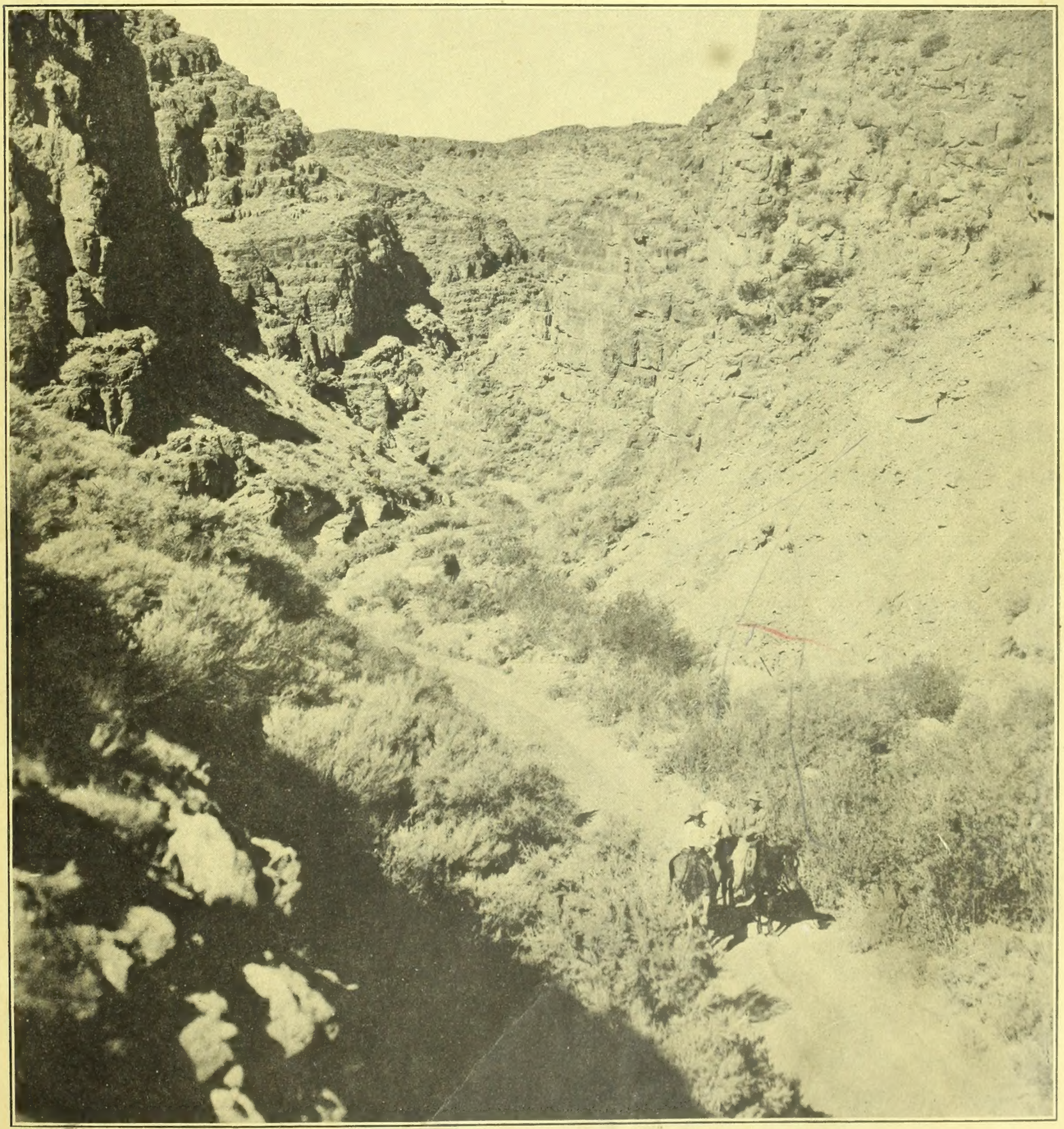
U.S. DEPARTMENT OF AGRICULTURE

VOL. I,
No. 1.

MAY,
1918.

PUBLIC ROADS

ISSUED BY
OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING



Looking down Salmon River canyon on an Idaho Federal Aid project.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING.

Logan Waller Page . . . . Director.
P. St. J. Wilson . . . Chief Engineer.
J. E. Pennybacker . Chief of Management.
Jules L. Goldberg . . . . . . Editor.

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SALUTATORY.

WITH this issue of PUBLIC ROADS the Office of Public Roads and Rural Engineering inaugurates the publication of a periodical devoted to better highways in the States of the Union and dedicated to those, both in official and private life, who are concerned in developing means of better rural communication, in facilitating the marketing of the crops of the Nation, and in aiding in the solution of the daily more perplexing traffic problem. If it may help in even a small measure toward the stimulation of ideas making for a standardization of effort in road construction and maintenance during the stressful period through which the civilized world is passing then, indeed, will it be justified, will it be a source of satisfaction to both its sponsors and supporters. But even to approach the attainment of its ends there must be between PUBLIC ROADS and those to whom it is dedicated a free and unrestricted interchange of honest, unbiased thought, and open mindedness to helpful suggestion, and a manful disposition to give and take constructive criticism, and with a single purpose—the greatest good for the greatest number.

It is not the purpose to allow this publication to supersede the bulletins issued intermittently by this Office since its establishment. Rather is it the purpose to supplement these bulletins and add to their value by the regular and frequent incorporation in these pages of the results of researches, experiments, and studies of those connected with this Office, and of highway officials of the various States who have in mind the ambition and at heart the desire to advance to as near perfection as possible the science of road building. It is not the desire of this Office from its position as a Federal institution to pose through the pages of this publication as a dictator in respect to highway affairs, nor as a mentor or a pedagogue, but rather to give, through the superior facilities at its disposition through the Federal Government, the best of the results of its researches, studies, and efforts periodically, rather than at long intervals, as has been the practice through the publication of bulletins. It is the desire to make this publication helpful to builders of highways, official and private, in both high and low stations. And in return it offers its columns and invites their use for the dissemination of such information as the officials of the various States may desire to spread for the benefit of their contemporaries. And by the liberal use of its pages for this purpose will it gain in value.

With increasing interest among the State highway officials in the Federal aid road act and the rapidly spreading desire to apply the benefits of this act to the roads of their States it becomes necessary to preserve a progress record of the projects under it. In this number will be found a complete compilation from the record of every State project submitted up to and including February 28, 1918, covering practically 18 months of progress under the act. A table will be carried in every issue, corrected and extended to the close of the month next preceding publication. Thus the highway officials of each State will have, in addition to the records preserved by them, the record of the Federal office in respect to their projects, and the story of the progress of Federally aided construction in every State in the Union.

It will be our earnest effort—always with the support and cooperation of the highway organizations of the States—to present matters of special interest to those directly concerned with the construction and maintenance of roads, to bring to all the progress of road improvement throughout the country, to discuss its problems and record its results. Always with the single purpose and devout hope that from this closer association will be born a determined and united disposition to bring to road betterment that which is best in and for this generation, that which, in this period in our history, will make for the greatest strength of our Nation, that which in fullest measure will aid those who are leading us in this strife to bring it to a speedy and victorious issue.

LOGAN WALLER PAGE,
Director.

FIFTY-TWO ON THE OFFICE ROLL OF HONOR.

Fifty-two stars decorating the field of the service flag on the front of Public Roads building mark the loss to the Office of the services of that many of its men and their entry into the service of the world in the mighty struggle. The force directly concerned with the construction of highways has contributed the largest number of men—18 in all—among them one district engineer, C. H. Sweetser. The Drainage Division has given an even dozen of its force, 6 have gone from Irrigation, 4 from the Laboratory, 2 from Rural Engineering, and the clerical force has been decreased by 10.

Every man of the 52 offered his life to his country. Not one was called in the draft. Almost every branch of the service and every rank from private to major is represented in the following list:

EMPLOYEES OF THE O. P. R. & R. E. WHO HAVE ENTERED MILITARY SERVICE.

Name.	Office Title	Rank.	Branch of Service.	Station so far as known.
Wallace Ashby	Barn Architect	1st Lieut.	Engineers Corps	
F. Russell Lyons	Jr. Highway Engineer	2nd Lieut.	Engineers Corps	Am. Expeditionary Force.
W. B. Booth	Jr. Drainage Engineer	2nd Lieut. U. S. R.	116th Engineers	Am. Expeditionary Force.
Q. C. Ayres	Jr. Drainage Engineer	2nd Lieut. U. S. R.	Co. B 1st U. S. Engineers	Am. Expeditionary Force.
O. N. Powell	Highway Engineer	Captain	Engineers Corps	Camp Lewis, American Lake, Wash.
Dan S. Helmick	Jr. Drainage Engineer	1st Lieut. U. S. R.	Co. B 1st U. S. Engineers	Am. Expeditionary Force.
Harris E. Petree	Clerk and Stenographer	1st Lieut. U. S. R.	13th Aero Squadron	Am. Expeditionary Force.
I. G. Kohlmeier	Clerk and Stenographer	Dental Surgeon	U. S. Navy	U. S. S. *Wyoming.*
A. L. Hooper	Jr. Highway Engineer	2nd Lieut. U. S. R.	Co. A, 25th Engineers	Am. Expeditionary Force.
P. A. Rideout	Jr. Highway Engineer	Sergeant	110th Engineers Corps	Am. Expeditionary Force.
R. E. Toms	Sr. Highway Engineer	Captain	Artillery	Ft. Sam Houston, Texas.
W. A. McCalla	Sr. Highway Engineer	Major	In Charge Road Battalion	
Wm. H. Rhodes	Sr. Highway Engineer	Captain	25th Engineers Corps, E. R. O. T. C.	Am. Expeditionary Force.
Wells A. Hutchins	Asst. Irrigation Engineer			Chickamauga, Ga.
J. H. Skeggs	Sr. Highway Engineer	Major	In Charge Road Battalion	Am. Expeditionary Force.
Geo. R. Boyd	Sr. Drainage Engineer	Captain U. S. R.	Unassigned	Am. Expeditionary Force.
J. H. Haswell	Sr. Drainage Engineer	Captain U. S. R.	Unassigned	Am. Expeditionary Force.
J. C. Stirton	Instrument Man	2nd Lieut.	E. O. R. C.	
C. E. Proudley	Laby. Asst.	Sergeant	Coast Artillery	
H. H. Barrows	Sr. Drainage Engineer	Captain U. S. R.	302nd Engineers	Camp Upton, N. Y.
C. F. Bessee	C. E. Draftsman	Private	361st Infantry	
Guy L. Smith	Jr. Drainage Engineer	2nd Lieut. U. S. R.	C. A. R. C.	Ft. Hamilton, N. Y.
L. A. Jones	Sr. Drainage Engineer	Captain U. S. R.	514 Service Battalion, R. O. T. C.	Camp Gordon, Ga.
Carl Rohwer	Asst. Irrigation Engineer			Ft. Riley, Kans.
Albert L. Lane	Jr. Drainage Engineer	1st Lieut. U. S. R.	Co. H. 50th Infantry	Camp Greene, Charlotte, N. C.
C. A. Miller	Draftsman	Corporal	Artillery	
I. D. Lucal	Clerk and Stenographer	Private	Hospital Corps	Ft. Sheridan, Ill.
Chas. H. Moorefield	Sr. Highway Engineer	Lieut.	Naval Reserve	Haiti.
H. H. MacPherson	Chief of Survey Party	1st Lieut.	Engineers Corps	
W. G. Franks	Clerk	Captain	Signal Corps	Ft. Bliss, El Paso, Tex.
W. B. Gregory	Irrigation Engineer	Major U. S. R.	Unassigned	Am. Expeditionary Force.
John H. Chapman	Clerk and Stenographer	Clerk	Signal Corps	Am. Expeditionary Force.
R. A. Brown	Supt. of Road Construction	Corporal	23rd Engineers Corps	
R. P. Sleight	Asst. Irrigation Engineer	1st Lieut.	Signal Corps	Washington, D. C.
W. M. Jeffrey	Jr. Highway Engineer	1st Lieut.	Engineers Corps	
W. H. Waugh	Sr. Highway Engineer	Captain	Engineers Corps	
D. O. Wolfe	Laby. Asst.	Cadet	Aviation Corps	
C. H. Sweetser	U. S. District Engineer	Captain	Engineers Corps	Camp Humphrey, Va.
S. L. Taylor	Jr. Highway Engineer	2nd Lieut.	E. R. O. T. C.	Camp Lee, Va.
W. G. Sloan	Drainage Engineer	1st Lieut.	E. R. O. T. C.	Camp Lee, Va.
O. G. Baxter	Sr. Drainage Engineer	Captain	E. R. O. T. C.	Camp Lee, Va.
F. G. Eason	Sr. Drainage Engineer	Captain	E. R. O. T. C.	Camp Lee, Va.
T. H. McCarthy	Asst. Irrigation Engineer		E. R. O. T. C.	Ft. Riley, Kans.
L. L. Beebe	Asst. Mechanical Engineer	Captain	Ordnance Corps	Camp Lee Va.,
Edw. Buckoff	Clerk		347th Engineers	
R. H. Harrison	Highway Engineer	Private	23rd Engineers	Camp Meade, Md.
J. R. Boyd	Laby. Apprentice	Private	Ordnance Corps	
D. L. McBeath	Supt. Road Construction	1st Lieut.	Engineers Corps	
H. S. Fairbank	Highway Engineer	1st Lieut.	Ordnance Corps	Edgewood, Md.
Wm. H. Barton, Jr.	Computor, Div. of Management	Corporal	Medical Corps	
W. P. Holland	Clerk	Cadet	Aviation Corps	
H. C. Diesem	Irrigation Engineer	Captain		

FIVE MILLION MOTOR CARS ON ROADS OF THE UNITED STATES.

Prepared in the Management Branch, Office of Public Roads and Rural Engineering.

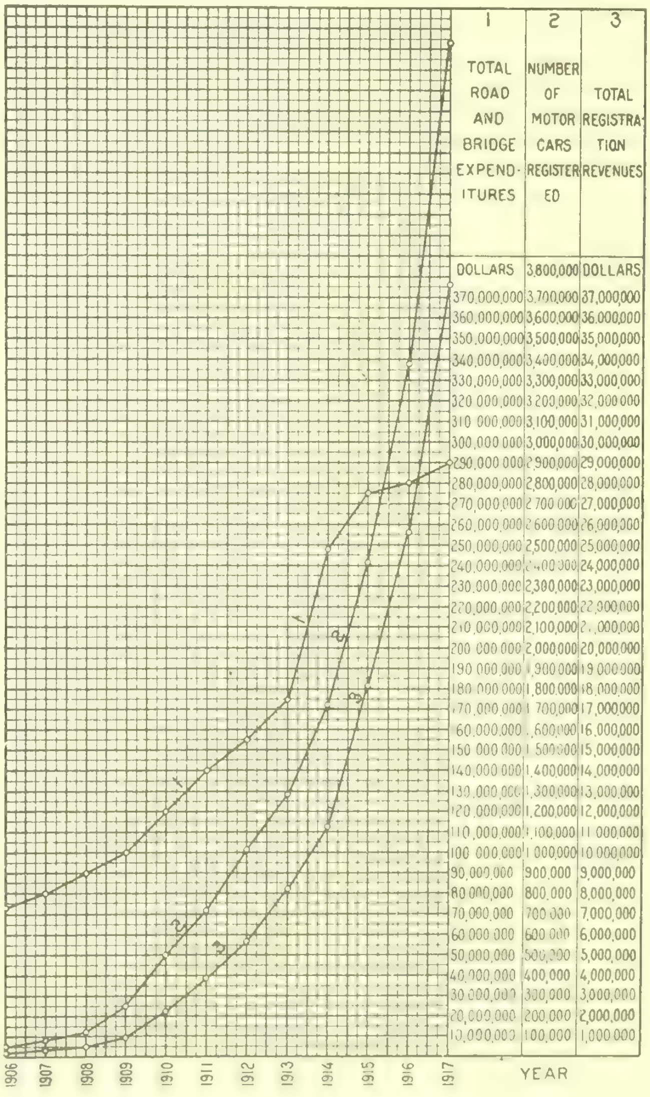
By

ANDREW P. ANDERSON, Highway Engineer.

A total of 4,983,340 motor cars, including commercial vehicles, and 257,522 motorcycles were registered in 1917 in the 48 States and the District of Columbia. The sum of $37,501,237 was collected in registration and license fees, including those of chauffeurs, operators, and dealers. As compared with 1916 this represents an increase of 1,470,344, or 44 per cent, in the number of cars and $11,637,867, or 45 per cent, in revenues. Approximately this same rate of increase over each preceding year has continued during the past five years. There is as yet no indication that either the curve for motor cars or that for the motor-vehicle registration revenues is approaching a maximum or has even reached the saturation point.

There is very little definite information available as to the number of motor cars in countries other than the United States. According to the best available data and estimate, however, about 85 per cent of all the motor cars at present in existence are in the United States. About 200,000 cars are in Canada, in all Provinces of which annual registrations now are in force. Probably 50,000 cars are found in all the rest of North and South America. The present number of cars in Europe is not known with any degree of accuracy. Estimates based on data available for 1914 would place the total number below 500,000, or about the same as the number of motor cars existing in the two States of New York and Connecticut. Thus, according to the best available data, nearly 90 per cent of all existing motor cars are in North and South America and about 10 per cent in all the rest of the world.

The increase in motor-car registrations and revenues in the United States during the past dozen years presents some interesting comparisons. This is true especially in regard to the use made of the registration revenues. In 1906 the total State registrations were approximately 48,000 cars, or less than one-hundredth of the present number and the revenues collected in the same year amounted to about $193,000, only slightly more than one two-hundredth of the total revenue collected in 1917. In 1906, however, the total gross revenues amounted to less than three-tenths of 1 per cent of the total rural road and bridge expenditures for that year, and, furthermore, only a small portion of this revenue was really applied to road work. In 1917, however, the total gross motor-vehicle revenue of $37,501,237 amounted to about 12 per cent of the total rural road and bridge expenditures, and of this nearly 93 per cent was applied directly to the improvement or maintenance of the public roads in 47 States. Of



Industry, saving, and lending to the Government are national needs and national duties.

the total amount applied to road work about 67 per cent, or $23,235,898, was expended more or less directly under the control or supervision of the State highway departments. The 7 per cent, or $2,812,633, not applied to road work was expended very largely for plates and in carrying out other administrative provisions of the motor-vehicle registration laws of the several States. The approximate relation and rates of increase of the three factors, total rural road and bridge expenditures, motor-vehicle registration and license revenues, and the number of motor-car registrations from 1903 to 1917, inclusive, are shown graphically in the accompanying chart.

TABLE I.—Motor-vehicle registrations, licenses, and revenue, 1917.

State.	Automobiles.	Motor trucks and commercial vehicles.	Motorcycles.	Reregistrations or transfers.	Owners' and chauffeurs' licenses.	Manufacturers' and dealers' licenses.	Motor-vehicle fines and penalties turned into State road fund.	Total gross motor-vehicle registration and license revenues.	Motor-vehicle revenues available for road work.		Average gross revenue return per motor car registration.	Population per motor car.	Motor cars per mile of public rural road.
									By or under State highway department.	Under direction of local authorities.			
Alabama	26,952	[1] 5,921	1,240		1,631	110		$217,700.00			$6.62	72	0.6
Arizona	19,890	(2)	868	1,037	911	230		117,643.00	$117,643.00		5.91	13	1.6
Arkansas	28,693	(2)		445	485		$354.00	205,176.50	191,175.00		7.15	62	.6
California	[3] 306,916	(2)	30,189		315,935	2,649		2,846,030.00	1,247,268.80	$1,247,268.80	9.27	10	5.0
Colorado	87,460	(2)	4,504	4,598	76,141	2,133		296,808.00	136,615.65	136,615.65	3.39	11	2.2
Connecticut	62,723	[4] 11,922	4,925	8,984	100,812	160	33,810.23	1,080,757.31	1,080,757.31		14.48	20	4.5
Delaware	10,700	(2)	730	1,045	12,590	510		133,883.00	83,883.00		12.51	20	2.9
District of Columbia	[5] 15,193	(2)	(2)		12,471			55,928.00			3.61	24	
Florida [6]	27,000	(2)	800					170,000.00	25,500.00	144,500.00	6.30	34	1.5
Georgia	70,324	(2)	1,600	1,284	4,190	586		229,653.00		143,514.00	3.27	11	.9
Idaho	23,771	960	752	313	1,182	497		412,641.48	103,160.37	309,481.11	16.69	18	1.0
Illinois	340,292	(2)	13,740		43,679	3,745		1,588,834.69	1,588,834.69		4.67	18	3.6
Indiana	192,194	(2)	10,315	2,562	5,063	1,121		1,096,159.08		899,818.07	5.70	15	2.6
Iowa	254,462	(2)	4,187	32,015		2,753		2,249,655.19	112,482.76	2,024,689.67	8.84	9	2.4
Kansas [7]	159,343	(2)	5,599			1,575		830,878.00		787,619.50	5.21	11	1.4
Kentucky	47,420	(2)	1,450		2,500			287,314.13	257,300.00		6.06	51	.8
Louisiana	28,394	(2)	382	352		403		166,834.67		150,151.32	5.88	65	1.2
Maine	38,117	3,382	1,516	(2)	47,568	442		491,696.30	487,873.00		11.84	19	1.8
Maryland	56,787	[8] 4,156	5,436	3,314	40,264	2,786	38,509.97	807,395.45	580,612.69	145,153.17	13.25	23	3.7
Massachusetts	147,310	26,964	11,065	(2)	214,229	2,379	83,640.00	1,969,994.00	1,731,552.00		11.30	21	9.3
Michigan	226,693	20,313	8,727	11,534	446,850	938		2,471,270.77	1,272,246.66	1,199,024.11	10.00	12	3.3
Minnesota	[9] 54,000	(2)	11,000	400	3,500	500		[6] 100,000.00	50,000.00		1.85	43	.6
Mississippi [6]	35,000	1,600	900		(10)			250,000.00		175,000.00	6.83	54	.8
Missouri	147,528	(2)	4,179	4,891	169,067	1,392		617,942.50	572,372.30		4.19	23	1.5
Montana	42,749	(2)	923	854	3,056	333		290,936.00	130,921.20	130,921.20	6.81	11	1.1
Nebraska	148,101	(2)	3,500			1,600		451,303.00		400,000.00	3.05	9	1.8
Nevada	6,885	275	215			46		31,166.00		31,166.00	4.35	16	.6
New Hampshire	[11] 22,267	(2)	2,218	2,400	27,645	197	3,974.82	425,305.09	376,773.63		19.10	20	1.6
New Jersey	131,964	[12] 6,951	13,198	26,114	177,568	1,242	54,664.25	1,923,163.63	1,887,965.21		13,55	21	9.6
New Mexico	14,086	(2)	345			161		80,843.50	35,739.34	35,739.34	5.74	31	1.2
New York	338,682	[16] 67,334	28,775		133,686	2,728		4,284,144.00	2,222,130.12	2,061,983.88	10.55	30	5.1
North Carolina	55,950	(2)	1,245	4,651		540		321,922.63	214,114.41	12,835.92	5.75	43	1.1
North Dakota	62,993	(2)	1,834	480		1,016		211,536.12	105,707.82	72,164.14	3.36	12	.9
Ohio	346,772	(2)	21,892	8,989		3,576		1,766,426.88	1,609,781.02		5.09	15	4.0
Oklahoma	100,199	(2)	2,368			1,500		853,658.91	768,293.02		8.52	23	.9
Oregon	48,632	(2)	3,400		3,476	375		196,787.50	167,834.34		4.05	18	1.3
Pennsylvania	[13] 306,001	[14] 19,152	24,567	23,287	178,417	7,891		3,268,025.50	3,268,025.50		10.05	27	3.6
Rhode Island	30,267	6,779	1,133	3,011	35,388	65	7,535.00	346,117.50	313,350.94		9.34	17	17.1
South Carolina	38,332	(2)	1,250	1,000		650		113,556.71	22,157.49	88,629.98	2.96	43	.9
South Dakota	67,158	(2)	1,554	1,900		1,012		210,592.00		179,003.20	3.14	11	.7
Tennessee	48,000	(2)	1,000	1,400		480		322,200.00	289,980.00		6.71	48	1.0
Texas [7]	192,961	(2)	3,468	6,359	12,714	10,008		858,978.50	720,119.85		4.45	24	1.5
Utah	21,576	2,500	1,385	100	1,547	161		170,707.25	[15] 170,707.25		7.09	19	2.4
Vermont	20,367	1,266	758	1,817	23,265	167		363,540.93	326,032.00		16.80	17	1.4
Virginia	55,661	(2)	2,135	(2)	3,530	400		518,565.84	492,170.47		9.32	40	1.0
Washington	79,680	11,657	6,320			2,385		519,526.00		435,129.00	5.69	18	2.2
West Virginia	31,300	(2)	825	1,250	2,713	525		359,339.45	276,048.62		11.48	46	1.0
Wisconsin	158,637	(2)	8,458	4,663		2,171		861,278.00	198,768.36	596,305.07	5.43	16	2.1
Wyoming	12,523	(2)	352			115		57,421.00		45,992.80	4.59	15	.8
Total	4,792,205	[17] 191,135	257,522	[17] 162,019	[17] 2,101,073	64,253	[17] 222,488.27	37,501,237.01	23,235,897.82	11,452,705.93	7.62	21	2.0

[1] Includes all trucks and cars used for hire.
[2] Included under automobiles.
[3] Does not include 2,750 nonresident and 5,134 exempt cars.
[4] Does not include 2,038 public-service registrations.
[5] Includes motor trucks and motor cycles.
[6] Approximate; exact data not obtainable.
[7] Includes only period from July 1 to December 31.
[8] Does not include 3,051 hiring and bus licenses.
[9] Registrations during 1917. Total registrations for 3-year period, 192,000.
[10] Registration not required.
[11] Does not include 1,721 nonresident registrations.
[12] Includes only cars weighing more than 4,000.
[13] Does not include 2,827 tractors and 854 trailers.
[14] Includes only vehicles with solid tires.
[15] Used to pay interest and sinking fund on $2,000,000 road bond.
[16] Includes 11,932 omnibuses.
[17] Partial totals.

On January 1, 1918, all but two States, Minnesota and Mississippi, had made provision for some definite form of annual State registration. In Minnesota the registrations are for a three-year period, the first of which closed December 31, 1917. In Mississippi the State registrations are perennial, but an annual county privilege license is required. Texas and South Carolina, which previously had only local registrations, made provision in 1917 for annual State registrations.

At present all or a major portion of the motor-vehicle revenues are applied to road work in all the States, except Alabama and the District of Columbia, in which cases the revenues go to the general fund. The tendency last year toward placing the expenditure of the motor-vehicle revenues directly in the hands of the State highway departments was very marked. Thus, Delaware, Florida, Nevada, North Carolina, North Dakota, Oregon, South Carolina, Texas, and West Virginia, each enacted legislation providing for this feature. Other States, among which may be mentioned Missouri, Tennessee, and Wisconsin, greatly increased the powers of the highway departments over the control of the motor-vehicle revenues. In the following 26 States all or a major portion of the net motor-vehicle revenues of 1917 were expended by or under the supervision or the direction of the State highway departments: Arizona, Connecticut, Delaware, Illinois, Kentucky, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Hampshire, New Jersey, North Carolina, North Dakota, Ohio, Oregon, Oklahoma, Pennsylvania, Rhode Island, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, and Wisconsin.

TABLE II.—Motor-car registrations and gross motor-vehicle revenues, 1913 to 1917.

	Motor-car registration.[1]						Total gross revenues.				
	1913	1914	1915	1916	1917		1913	1914	1915	1916	1917
Alabama	5,300	8,672	11,634	21,636	32,873	Alabama	$83,000	$113,202	$180,744	$203,655	$217,700
Arizona	3,613	5,040	7,753	12,300	19,890	Arizona	27,545	34,077	45,579	73,000	117,643
Arkansas	3,583	5,642	8,021	15,000	28,693	Arkansas	17,411	56,420	80,551	150,000	205,176
California	[2] 100,000	123,504	163,797	232,440	306,916	California	75,000	1,338,785	2,027,432	2,192,699	2,846,030
Colorado	13,000	17,756	28,894	43,296	87,460	Colorado	60,833	80,047	120,801	197,795	296,808
Connecticut	23,200	27,786	41,121	56,048	74,645	Connecticut	316,677	406,623	536,970	768,728	1,080,757
Delaware	2,440	3,050	5,052	7,102	10,700	Delaware	24,735	35,672	55,596	85,249	133,883
Dist. of Columbia	4,000	4,833	8,009	13,118	15,493	Dist. of Columbia	13,228	20,147	29,396	47,624	55,928
Florida	[3] 3,000	[3] 3,368	[3] 10,850	20,718	[2] 27,000	Florida	[4] 6,000	[4] 6,736	[2] 60,000	127,176	[2] 170,000
Georgia	[2] 20,000	20,915	25,000	46,025	70,324	Georgia	12,000	104,575	125,000	154,735	229,653
Idaho	2,113	3,346	7,071	12,999	24,731	Idaho	35,160	58,580	121,259	213,758	412,641
Illinois	94,656	131,140	180,832	248,429	340,292	Illinois	507,629	699,725	924,906	1,236,566	1,588,835
Indiana	45,000	66,500	96,915	139,065	192,194	Indiana	150,345	432,309	587,318	817,285	1,096,159
Iowa	70,299	106,087	145,109	198,587	254,462	Iowa	787,411	1,040,136	1,533,054	1,776,170	2,249,655
Kansas	34,550	49,374	72,520	112,122	159,343	Kansas	186,066	268,471	387,588	585,762	830,878
Kentucky	7,210	11,766	19,500	31,500	47,420	Kentucky	52,000	85,883	117,117	184,741	287,314
Louisiana	[2] 10,000	[2] 12,000	11,380	17,000	28,394	Louisiana	[2] 10,000	[2] 12,000	75,600	112,000	166,835
Maine	11,022	15,700	21,545	30,972	41,499	Maine	138,509	192,542	268,412	363,562	491,696
Maryland	14,217	20,213	31,047	44,245	60,943	Maryland	150,000	268,231	386.565	565,302	807,395
Massachusetts	62,660	77,246	102,633	136,809	174,274	Massachusetts	764,154	923,961	1,235,724	1,602,958	1,969,994
Michigan	54,366	76,389	114,845	160,052	247,006	Michigan	190,329	(4)	373,833	1,739,344	2,471,271
Minnesota	46,000	67,862	93,269	[5] 46,000	[9] 51,009	Minnesota	40,000	132,398	[2] 160,540	82,469	100,000
Mississippi [2]	[2] 3,850	5,694	9,669	25,000	36,600	Mississippi [2]	....	51,146	76,700	175,000	250,000
Missouri	38,140	54,468	76,462	103,587	147,528	Missouri	173,510	235,873	323,289	439,315	617,942
Montana	5,916	10,200	14,540	25,105	42,749	Montana	12,000	27,000	33,120	52,768	290,936
Nebraska	13,411	16,385	59,000	101,200	148,101	Nebraska	26,000	34,325	[2] 183,000	311,334	451,303
Nevada	1,091	1,487	2,009	4,919	7,160	Nevada	3,323	4,331	7,875	20,116	31,166
New Hampshire	8,237	9,571	13,449	17,508	22,267	New Hampshire	152,834	185,288	257,776	344,434	425,305
New Jersey	51,360	62,961	81,848	109,414	141,918	New Jersey	661,446	814,536	1,062,923	1,406,806	1,923,164
New Mexico	1,898	3,090	5,100	8,228	14,086	New Mexico	15,084	19,663	29,625	47,865	80,843
New York	134,495	168,223	255,242	314,222	406,016	New York	1,275,727	1,529,852	1,991,181	2,658,042	4,284,144
North Carolina	10,000	14,677	21,000	33,904	55,950	North Carolina	60,000	89,580	123,000	206,101	321,923
North Dakota	15,187	17,347	24,908	40,446	62,993	North Dakota	41,961	55,964	79,245	125,283	211,536
Ohio	86,156	122,504	181,332	252,431	346,772	Ohio	457,538	685,457	984,622	1,286,105	1,766,427
Oklahoma	[2] 3,000	13,500	25,032	52,718	100,199	Oklahoma	3,000	13,500	154,892	555,011	853,659
Oregon	13,975	16,447	23,585	33,917	48,632	Oregon	56,873	77,592	108,881	146,232	196,787
Pennsylvania	80,178	112,854	160,137	230,578	325,153	Pennsylvania	841,062	1,185,039	1,665,276	2,325,057	3,268,025
Rhode Island	10,295	12,331	16,362	21,406	37,046	Rhode Island	129,851	157,020	206,440	261,737	346,117
South Carolina [2]	10,000	14,000	15,000	[6] 25,000	38,332	South Carolina [2]	10,000	11,000	15,000	10,000	113,557
South Dakota	14,457	20,929	28,724	44,271	67,158	South Dakota	89,170	125,000	[2] 180,000	140,746	210,592
Tennessee	[2] 10,000	[7] 19,769	[8] 7,618	[2] 30,000	48,000	Tennessee	[2] 9,000	39,538	[2] 34,000	186,953	322,200
Texas [2]	32,000	40,000	40,000	[6] 125,000	192,961	Texas [2]	16,000	20,000	20,000	20,000	858,978
Utah	4,000	2,253	9,177	13,507	24,076	Utah	3,000	4,852	[2] 60,000	93,494	170,707
Vermont	5,913	8,475	11,499	15,671	21,633	Vermont	111,460	154,267	218,480	297,992	363,541
Virginia	9,022	13,984	21,357	35,426	55,661	Virginia	83,611	120,814	176,875	271,266	518,566
Washington	24,178	30,253	38,823	60,734	91,337	Washington	48,356	60,506	238,717	350,052	519,526
West Virginia	5,144	6,159	13,279	20,571	31,300	West Virginia	40,000	60,648	128,952	198,436	359,339
Wisconsin	34,346	53,161	79,741	115,645	158,637	Wisconsin	190,770	293,580	431,977	615,721	861,278
Wyoming	1,584	2,428	3,976	7,125	12,523	Wyoming	7,920	12,140	19,880	35,625	57,421
Total	1,258,062	1,711,339	2,445,664	3,512,996	4,983,340	Total	8,192,253	12,381,951	18,245,711	25,865,370	37,501,233

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[1] Does not include motor cycles nor dealers' and manufacturers' licenses.
[2] Estimated.
[3] State registrations only.
[4] Registration law declared unconstitutional.
[5] Cars registered during 1916; total number of cars, approximately 138,000.
[6] Estimated number of cars in State.
[7] Total cars registered under perennial system.
[8] Registrations 1915 only.
[9] Cars registered, 1917.

In Arkansas, California, Colorado, Idaho, Michigan, Montana, New Mexico, and New York one-fourth to one-half of the State motor-vehicle revenues were expended either by or under the direct supervision of the State highway departments and the remainder by the local authorities. The 10 States in which the State government exercised no appreciable direct supervision or control over any of the net automobile revenues, and which are not included in the above classification, are Alabama, Georgia, Indiana, Kansas, Louisiana, Mississippi, Nebraska,

The determining factor in the outcome of this war is the organized might of America. Work, save, and lend to the Government.

TABLE III.—Motor-vehicle registration and license fees in force January 1, 1918.

State.	Motorcycles.	Pleasure cars.	Motor trucks and commercial cars.	Chauffeurs.	Owner operators.	Dealers and manufacturers.
Alabama	$3; with side-car attachment, $5.	Less than 25 horsepower, $7.50; 25 to 29 horsepower, $12.50; 30 to 39 horsepower, $17.50; 40 horsepower and over, $20; electric cars, $12.50; steam cars, $15.	Same as pleasure cars, except that those over 40 horsepower pay $25 each.[1]	Original, $5; renewal, $2.50.	None	$25 to $125.
Arizona	$2	25 horsepower and under, $5; 26 to 40 horsepower, $10; over 40 horsepower, $15.	Same as pleasure cars	Perpetual, $5.	..do.	1 vehicle of each class at pleasure-car rates.
Arkansas	None	All motor vehicles, $10	..do	$1	..do	Do.
California	$2	Electric cars, $5; all others, 40 cents per horsepower; trailers, $2.	Equipped with pneumatic tires, same as pleasure cars; others pay additional; less than 2 tons unloaded, $5; 2 to 3 tons, $10; 3 to 5 tons, $15; over 5 tons, $20.	Original, $2; renewal, $1.	No fee	5 cars, $25, and $2 for each additional; motorcycles, $5.
Colorado	$2.	20 horsepower and under, $2.50; 21 to 40 horsepower, $5; 41 horsepower and over, $10.	Same as pleasure cars	$1.	None.	5 cars, $5.
Connecticut	$2	50 cents per horsepower	½ ton or less, $11; 1 ton, $15, and increasing to $225 for 10 tons, and $50 per ton for each ton additional.	License, $2; examination, $2.	License, $2; examination, $2.	Motorcycles, $10; others, $50.[2]
Delaware	$5	$2 each 500 pounds gross weight of car and load; passengers figured at 125 pounds each.	Same as pleasure cars	$3.	$3; family, $8.	$20 for 2 pairs of tags; extra tags, $10 pair.
District of Columbia.	$2.	24 horsepower or less, $3; 25 to 30 horsepower, $5; over 30 horsepower, $10.	..do	$2	$2	Regular rates for each car demonstrated on public roads.
Florida (3)	$2	Cars seating not more than 5 persons, $5; 25 to 40 horsepower, $12; 41 to 60 horsepower, $15; over 60 horsepower, $30; any car seating more than 10 persons, $100.	1 ton or less, $10; 1 to 2 tons, $25; 2 to 4 tons, $35; more than 4 tons, $100.	$2.	None.	5 cars, $15
Georgia.	$2	Not exceeding 25 horsepower, $3; 26 to 40 horsepower, $4; over 40 horsepower, $5; electric cars, $4.	Not exceeding 1 ton weight, $3; not exceeding 3 tons, $4; not exceeding 5 tons, $5; exceeding 5 tons, $6	$2.	.do	$10 for 2 number plates and $1 for each duplicate.
Idaho	$5	All weighing less than 2,001 pounds, $15; 2,001 to 3,000 pounds, $20; 3,001 to 4,000 pounds, $30; over 4,000 pounds, $40.	Same as pleasure cars.	$2	.do.	$35 for one make and $25 each additional make.
Illinois (6)	$3	10 horsepower or less, $4.50; 11 to 25 horsepower, $6; 26 to 35 horsepower, $9; 36 to 50 horsepower, $16; over 50 horsepower, $20; electric cars of 2 tons capacity or less, $10; over 2 tons capacity, $20.	.do.	Original, $5; renewal, $3.	.do.	$10 for 2 plates and $10 for each pair duplicates.
Indiana.	$2.	Electric cars, $3; others, 25 horsepower or less, $5; 26 to 40 horsepower, $8; 41 to 50 horsepower, $15; over 50 horsepower, $20.	All commercial cars, $5.	$2	.do	$25; duplicate plates, $1 each.
Iowa.	$3	20 horsepower or less, $8; over 20 horsepower, 40 cents per horsepower; all electric and steam cars, $15 each.	Same as pleasure car	None	.do.	$15.
Kansas.	$2	All cars, $5 each	..do	do.	.do	$15 for 3 sets of tags; extra tags, 50 cents each.
Kentucky	$[illegible]	Less than 25 horsepower, $6; 25 to 50 horsepower, $11; 50 horsepower and over, $20.	..do.	Original, $2; renewal, $1.	..do.	1 registration for each class at regular rates.
Louisiana	$2	25 cents per horsepower, with a minimum fee of $5 per car	All motor trucks, $7.50 each.	None	..do.	1 regular registration for each make; second-hand dealers, $10.
Maine	$3	15 horsepower or less, $5; 16 to 35 horsepower, $10; over 35 horsepower, $15.	Commercial cars, $10.	$2.	$2.	$25 for 5 pairs of plates; extra plates, 75 cents each.
Maryland.	$3	50 cents per horsepower; minimum charge, $5; $1 per horsepower if operated for hire.	Trucks with solid tires and rated capacity of not more than 1 ton, $8; for each additional ton capacity, $6; trailers, $5 each.	$3.	$2.	$20 for 2 sets of tags and $10 for each additional set. For dealers in motorcycles, 4 tags, $8; additional tags, $2 each.
Massachusetts	$2	Under 20 horsepower, $5; 20 to 29 horsepower, $10; 30 to 39 horsepower, $15; 40 to 49 horsepower, $20; 50 horsepower and over, $25.	Trucks under 1 ton, $5, and $3 for each additional ton.	Original, $2; renewal, 50 cents; examination, $2.	Original, $2; renewal, 50 cents.	$10, motorcycles; $25, motor vehicles, and $5 additional for each car over 5 operated on public roads.
Michigan	(4)	Electric cars, $1 for each motor horsepower plus 25 cents for each 100 pounds of weight; others, 25 cents per horsepower plus 25 cents for each 100 pounds of weight.	Electrics, 50 cents per motor horsepower plus 25 cents for each 100 pounds of weight; others, 15 cents per horsepower plus 15 cents per 100 pounds of weight.	$2	None	$50 for 5 cars and $10 for each additional car.[5]
Minnesota	$5	All cars, $5	Same as pleasure cars	Original, $1.50; renewal, $1.	do	$20; extra plates, $1 per set.
Mississippi.	State, $2; county, $2.40.	State, $2; county, electric cars, $4.80; others, 36 cents per horsepower.	4,400 pounds capacity or less, $8.40; over 4,400 pounds, $16.80.	None	..do.	Regular rates for 4 sets of plates.

[1] Cars used for transportation of passengers paying fare, 5 or less passenger capacity, $25; 6 to 9 passenger capacity, $40; 10 or more passenger capacity, $60; operating between towns or cities 10 miles or more apart, a flat fee of $40.

[2] In case of manufacturers, $25, plus $1 for each car tested on public roads.

[3] Any county or municipality may charge an additional license tax, not to exceed 50 per cent of State license tax, on motor vehicles used for hire.

[4] Same rate as pleasure cars.

[5] In case of manufacturers, motorcycles $20, including 10 number plates.

[6] Both cars and trucks may be registered in municipality in which owner resides.

TABLE III.—Motor-vehicle registration and license fees in force January 1, 1918—Continued.

State.	Motorcycles.	Pleasure cars.	Motor trucks and commercial cars.	Chauffeurs.	Owner operators.	Dealers and manufacturers.
Missouri	(1)	Less than 12 horsepower, $1; $12 to 23 horsepower, $6; 24 to 35 horsepower, $10; 36 to 47 horsepower, $14; 48 to 59 horsepower, $16; 60 to 71 horsepower, $20; 72 horsepower and over, $24.	Same as pleasure cars	$1.50	None	$10; for each duplicate, $5.
Montana	$5	23 horsepower or less, $5; 24 to to 50 horsepower, $10; over 50 horsepower, $15.	One ton capacity or less, $5; over 1 ton and less than 2, $15, over 2 tons and less than 3, $25, over 3 tons, $40.	$2	do	Cars, $50; motorcycles, $15.
Nebraska	$2	All cars $3 each	All $5 each	None	do	Registration for each class, $5.
Nevada	$3	20 horsepower or less, $3; 21 to 40 horsepower, $5.50; over 40 horsepower, $8.	Same as pleasure cars	do	do	$10 for 4 number plates; $1 for each duplicate.
New Hampshire	$2	15 horsepower or less, $10; 16 to 30 horsepower, $15; 31 to 40 horsepower, $20; 41 to 50 horsepower, $25; 51 to 60 horsepower, $30; over 60 horsepower, $40.	do	Original, $5; renewal, $1.	Original, $3; renewal, $1.	Cars, $50; motorcycles, $5;
New Jersey	$2	10 horsepower or less, $4.50; 11 to 29 horsepower, $7.50; 30 horsepower or over, $15.	With solid tires loaded weight 2 tons or less, $15, and $2 additional for each one-half ton gross weight over 2 tons; trailers, $3.	$3	$3	$ per car not to exceed 5.
New Mexico	$2	Less than 12 horsepower, $2; 12 to 19 horsepower, $4; 20 to 29 horsepower; $6. 30 to 39 horsepower, $8; 40 to 49 horsepower, $10; 50 horsepower or over, $12.	Same as pleasure cars	None	None	$12.
New York	$2.50	25 horsepower or less, $5; 26 to 34 horsepower, $10; 35 to 49 horsepower, $15; 50 horsepower and more, $25.	Gross loaded weight 2 tons or less, $10, and $5 each additional ton to 14; 14 tons, $70, and $10 each additional ton.	Original, $3; renewal, $2; examination, $2.	do	$15, plus $1 for each duplicate tag.
North Carolina	$2	26 horsepower or less, $5; 26 to 40 horsepower, $7.50; over 40 horsepower, $10.	Same as pleasure cars	None	do	$10, plus $1 for each duplicate plate.
North Dakota	$3	20 horsepower or less, $6, and 50 cents additional for each horsepower above 20.	do	do	do	$15; extra plates, 50 cents per set.
Ohio	$2	Electric cars, $3; all others, $5.	do	$3	do	$10 each make of motorcycle and $20 each make of automobile.
Oklahoma	(1)	50 cents per horsepower first year; second, 40 cents per horsepower; third, 30 cents per horsepower; and thereafter, 20 cents per horsepower.	do	None	do	$15 for 2 tags and $1 each for additional tags.
Oregon	$3	Electric cars, $6; others, 26 horsepower and less, $6; 27 to 36 horsepower, $10; 37 to 40 horsepower, $15; above 40 horsepower, $20.	Electric trucks, $10; others 1½ to 2 tons, $15, and $3 for each additional one-half ton up to 5 tons; over 5 tons allowed only on special permits.	$2	do	$10 for 2 tags and $2.50 for duplicate sets.
Pennsylvania	$3	Less than 20 horsepower, $5; 20 to 34 horsepower, $10; 35 to 49 horsepower, $15; 50 horsepower and above, $20.	With pneumatic tires, same as pleasure cars; others, including load, less than 2 tons, $5; 2 to 2½ tons, $10; 2½ to 5 tons, $15; 5 to 7½ tons, $20; 7½ to 12 tons, $25; trailers, including load, less than 5 tons, $3; 5 to 12 tons, $5.	$2	No fee	$10.
Rhode Island	$2	15 horsepower or less, $5; 16 to 30 horsepower, $10; 31 to 40 horsepower, $15; over 40 horsepower, $25.	Carrying capacity 1 ton or less, $7, with $3 additional for each ton to 4 tons, and then $4 for each ton above 4 tons; over 9-ton capacity, $40 each; trailers, $10 to $30 each.	$1	$1	$25 for 5 vehicles and $5 for each additional vehicle.
South Carolina	(1)	25 cents per horsepower	Same as pleasure cars	None	None	$15 for each make.
South Dakota	$2	All cars $3 each	No registration required	do	do	$5.
Tennessee	(1)	30 cents per horsepower	30 cents per horsepower plus $3 per ton carrying capacity.	do	do	$10.
Texas	$3	35 cents per horsepower	Same as pleasure cars except when used for hire.	$3	do	$15; extra numbers, $5 each.
Utah	$3	Electric cars, $10; others 25 horsepower and less, $5; 26 to 40 horsepower, $10; above 40 horsepower, $15.	$10	$2	do	$25, and $2 for each set of duplicate plates.
Vermont	(1)	First registration, $1 per horsepower; second, 75 cents per horsepower; third registration and thereafter, 50 cents per horsepower.	Same as pleasure cars	$3	$2	$50.
Virginia	(1)	40 cents per horsepower	do	$2.50	None	$50.
Washington	$2.50	25 horsepower and less, $5; 26 to 39 horsepower, $7.50; 40 horsepower and over, $10.	Automobiles and busses for hire, $1 per horsepower, motor trucks under one-half ton capacity, $5; 1 ton, $10; 2 tons, $15; 3 tons, $25; 4 tons, $35; 5 tons, $50; 6 tons, $100; 7 tons, $250.	None	do	Cars, $25; extra plates, $5 per pair; motorcycles, $3.
West Virginia	$5	Cars weighing 1 ton or less, $10, and 25 cents additional for each 100 pounds over 1 ton.	Same as pleasure cars	$3	do	Cars, $15 per set of plates; motor cycles, $5.
Wisconsin	$4	All cars $10 each	Capacity less than 2,100 pounds, $15; 2,100 to 5,100 pounds, $20; 5,100 pounds or more, $25.	(2)	do	$25.
Wyoming	$2.50	All cars $10 each	Same as pleasure cars	None	do	$10 for 4 plates, $1 for each additional plate.

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[1] Same rate as pleasure cars.

[2] Drivers of cars operating for hire may be licensed by municipality.

TABLE IV.—Administrative provisions in force January 1, 1918, affecting motor-vehicle registrations, licenses, and revenues.

State.	Registration and licenses.					Revenues from registrations and licenses.				Traffic regulations made by—
	Official or department in charge.	Renewals.		Requirements for operators' and chauffeurs' licenses.	Nonresidents' exemptions.	Applied to	Proportion expended for roads under supervision of		Revenues from fines and penalties applied to roads.	
		Car registrations.	Operators' and chauffeurs' licenses.				State highway department.	Local road authorities.		
Alabama	State board of equalization through probate judge.	Annual, Oct. 1.	Chauffeur, annual, Oct. 1.	Chauffeur must be 18 years old.	Reciprocity.	State, county, and city general funds.	None	None	None	Statute.
Arizona	Secretary of state.	Annual, Jan. 1	Chauffeur, perpetual.	No examination.	6 months	State road tax fund.	All of net.	do	..do	Statute and local ordinance.
Arkansas	Commissioner of state lands, highways, and improvements.	do	Chauffeur, annual from date.	Chauffeur must be 18 years old.	Reciprocity	State and county road fund.	One-half	One-half	One-half of penalty for delinquency.	Do.
California	Superintendent of motor-vehicle department.	do	Chauffeur, annual.	do	3 months	State and county road work	One-half net.	One-half net.	All, by local community.	Do.
Colorado	Secretary of state.	do	Chauffeur, annual, Jan. 1.	No examination	90 days	do	..do	...do	Same as registration revenues.	Do.
Connecticut	Commissioner of motor vehicles	do	All operators, annual, Mar. 1.	Examination	No limit	Maintenance State roads.	All of net	None	..do	Do.
Delaware	Secretary of state	do	All operators, Jan. 1.	Must be 16 old; no examination.	Reciprocity.	State highway department.	All	...do	None	Do.
District of Columbia.	Automobile board	...do	All operators, perpetual.	Examination	do	General fund	None	do	....do	
Florida	State comptroller	...do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	Reciprocity.	State highway department and State maintenance fund.	All of net	...do	....do	Do.
Georgia	Secretary of state	Annual, Mar. 1.	Chauffeur, annual, Mar. 1.	Must be 16 years old	30 days	Net to State road fund for apportionment to counties.	None	All of net	.do	Do.
Idaho	State highway commission through county assessor.	Annual, Jan. 1.	Chauffeur, annual.	Chauffeur, must be 18 years of age.	Reciprocity	State highway fund.	25 per cent.	75 per cent.	Same as registration revenues.	Do.
Illinois	Secretary of state	...do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	60 days	State "road fund."	All	None	All, by local community.	Do.
Indiana	.do.	.do.	.do.	...do	.do.	Net, county road work.	None	All of net	Same as registration revenues.	Do.
Iowa	.do.	do	None	Must be 15 years of age.	Reciprocity.	State and local road work.	(2)	(2)	Local road work.	Do.
Kansas	Secretary of state through county treasurer.	Annual, July 1.	do	Must be 14 years of age.	30 days	Net, maintenance county and township roads.	None	All of net	None	Statute and city ordinance.
Kentucky	Commissioner of motor vehicles.	Annual, Jan. 1.	Chauffeur, annual, Jan. 1.	Chauffeur, examination	Reciprocity.	Net to State road fund.	All of net	None	..do	Statute and local ordinance.
Louisiana	Secretary of state	...do.	None.		...do	90 per cent to parish road work; 10 per cent for expenses.	None	90 per cent gross.	Same as registration revenues.	Local ordinance.
Maine	do	..do	All operators, annual, Jan.	Examination optional.	30 days	State road work.	All	None	None	Statute and local ordi-
Maryland	Commissioner of motor vehicles.	..do	Owner, perpetual; chauffeur, annual	.do	Reciprocity, two periods of 7 days each.	Net 20 per cent Baltimore street work; 80 per cent State road maintenance.	80 per cent of net.	...do	Same as registration revenues.	Do.
Massachusetts	State highway commissioner	..do	All operators, annual from date.	Chauffeur, examination.	Reciprocity.	Net 20 per cent small town roads; 80 per cent maintenance State roads.	All net	...do	..do	Statute, State highway commission, and local ordinance.
Michigan	Secretary of state	.do	Chauffeur, annual. Jan. 1.	No examination.	Reciprocity to 90 days.	State and county road work.	One-half net.	One-half net.	None	Statute and local ordinance.
Minnesota	....do	Triennial	do.	Chauffeur, examination.	30 days	Net, State road and bridge fund.	All net	None	..do	Do.
Mississippi[1]	State auditor and county tax collector.	Perennial with State; annual Jan. 1 with county.	None		60 days.	State revenues to general fund; county to county road work.	None	Net county revenue.	Net, same as county revenue.	Local ordinance.
Missouri	Secretary of state	Annual, Feb. 1.	Chauffeur, annual, Feb. 1.	Must be 18 years of age; no examination.	...do	State road fund	All of net.	None	None	Statutes and local ordinance.
Montana	do	Annual, Jan. 1	Chauffeur, annual, Jan. 1.	No examination.	No limit.	Net to State and county road work.	One-half net.	One-half net.	..do	Do.

[1] After 3 years' fee reduced to one-half.

[2] Sufficient funds set aside to meet Federal aid, provide maintenance of highway department and expenses of registration: remainder to counties for road work.

TABLE IV.—Administrative provisions in force January 1, 1918, affecting motor-vehicle registrations, licenses, and revenues—Continued.

	Registration and licenses.					Revenues from registrations and licenses.				
State.	Official or department in charge.	Renewals.		Requirements for operators' and chauffeurs' licenses.	Nonresidents' exemptions.	Applied to.	Proportion expended for roads under supervision of—		Revenue from fines and penalties applied to roads.	Traffic regulation fixed by.
		Car registrations.	Operators' and chauffeurs' licenses.				State highway department.	Local road authorities.		
Nebraska	Secretary of state through county treasurer.	Annual, Jan. 1.	None.	Must be 16 years old.	30 days.	Net to county road work.	None	All net.	None.	Statute and local ordinance.
Nevada	Secretary of state.	do	do.		do.	Net to State road work.	All net.	None.	do.	Do.
New Hampshire.	Commissioner of motor vehicles.	do	All operators, annual, Jan.	Examination, all operators.	20 days.	Road maintenance.	do	do	Same as registration revenues.	Do.
New Jersey	do	do	do	do	Reciprocity; 15 days.	do	do	do	do	Statute and motor vehicle commission.
New Mexico	Secretary of state.	do	None.	Must be 14 years old.	60 days.	Net State and county road work.	50 per cent net.	50 per cent net.	None.	Statute and local ordinance.
New York	do	Annual, Feb. 1.	Chauffeur, annual, Feb. 1.	Chauffeur, examination.	Reciprocity.	State and local road work.[1]	50 per cent gross.	50 per cent gross.	Maintenance of State roads.	Statute, State highway commission, and local ordinance.
North Carolina.	do	Annual, July 1.	None	Must be 16 years of age	Reciprocity to 60 days.	Net to State road maintenance.	All net.	None.	None	Statute and local ordinance.
North Dakota	do	Annual, Jan. 1.	do		No limit.	Net to State and county road work.	Two-thirds of net.	One-third of net.	do	Do.
Ohio	do	do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	do	Net to State road fund.	All net.	None.	do	Statute, State highway department, and local ordinance.
Oklahoma	Department of highways.	do	None		Reciprocity.	10 per cent appropriated for State highway department; 90 per cent county road work.	All.		All.	Statute and local ordinance.
Oregon	Secretary of state.	do	Chauffeur, annual, Jan. 1.	Must be 18 years of age; no examination.	30 days.	Net to Federal aid road work.	All net.	None.	County road fund.	Do.
Pennsylvania	State highway department.	do.	do	Affidavits as to competency.	Reciprocity.	State and State-aid road work.	All gross.	do	Certain ones locally.	Do.
Rhode Island.	State board of public roads.	do	All operators, annual from date.	Examination, all operators.	10 days.	Maintenance State roads.	All net.	do	Same as registration revenues.	State board of public roads statute and local ordinance.
South Carolina.	State highway engineer.	Annual, Jan. 1.			30 days.	Maintenance highway department and county road work.	20 per cent	80 per cent	None.	Statute and local ordinance.
South Dakota	Secretary of state through county treasurer.	do	do	Must be 15 years old.	Reciprocity.	85 per cent county road work.	do	85 per cent	do	Do.
Tennessee	State department of highways through county clerk.	do	do		30 days.	10 per cent to State highway department; 90 per cent to county road work.	All net.		Same as registration revenues.	Do.
Texas	State highway department.	do	Chauffeur, annual, Jan. 1.	Must be 18 years of age.	90 days.	All to State highway fund.	do	None	County road work.	Do.
Utah	Secretary of state.	Annual, Mar. 1.	do	No examination.	30 days.	Motor vehicle registration fund.	All net[2]	do	None.	Do.
Vermont	do	Annual, Jan. 1.	All operators, annual, Jan. 1.	Examination, chauffeur.	Reciprocity.	State maintenance fund.	do	do.	do	Do.
Virginia	Secretary of commonwealth.	do	Chauffeur, annual, Jan. 1.	No examination.	2 periods of 7 days each.	Net maintenance State aid roads.	do.	do	do	Do.
Washington	Secretary of state through county auditor.	Annual, Mar. 1.	None	Operators must be 15 years of age, chauffeurs 21.	90 days.	Net to permanent highway fund for maintenance.	None	All net.	Same as registration revenues.	Do.
West Virginia	State road commission.	Annual, July 1.	Chauffeur, annual, July 1.	Must be 17 years of age	Reciprocity.	State road fund.	All.	None	None	Do.
Wisconsin	Secretary of state.	Annual, Jan. 1.	None.	Must be 16 years of age[3]	Reciprocity	Net to State highway fund and county road work.	75 per cent net.	25 per cent net.	do	Do.
Wyoming	do	do	do	Must be 15 years of age.	Reciprocity to 90 days.	80 per cent to county road work.	None.	80 per cent	do	Statute.

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[1] Does not apply to revenue collected within New York City, one-half of which goes to city general fund.
[2] To pay interest and sinking fund on $2,000,000 State road bond.
[3] Drivers of cars operating for hire may be licensed by municipalities.

South Dakota, Washington, and Wyoming. The States of Florida, Iowa, Nevada, and South Carolina are not included in the above classification. Beginning January 1, 1918, the States of Florida and Nevada came into the first class and Iowa the second.

The total road mileage of the United States outside of incorporated towns and cities was 2,455,761 in 1917. With a registration of 4,983,340 motor vehicles there was, therefore, an average of two motor cars for each mile of rural public road in the United States. The distribution of cars among the several States, however, naturally varies a great deal. Thus, Arkansas and Nevada have but three cars to every 5 miles of road, while California has 5, Connecticut 4.5, Massachusetts 9.3, New Jersey 9.6, and Rhode Island 17.1 cars to each mile of rural road. While there was an average of one motor-car registration for every 21 persons in the United States, in the State of Iowa and Nebraska there was one car for every 9 persons, but only one for every 72 persons in Alabama, one for every 65 in Louisiana, and one for every 62 in Arkansas. The population per motor car and the number of motor cars per mile of public road are shown more fully in columns 12 and 13, Table 1.

There are still 21 States in which motor trucks are registered at the same rates as pleasure cars. But the past year has shown quite a decided tendency to increase the fees required for heavy motor trucks. This increase is based generally on either the weight of the truck, its carrying capacity, or a combination of its carrying capacity and its horsepower. However, there is no evidence of any well-defined goal toward which this movement is tending. The term motor truck and commercial vehicle, moreover, is very indefinite. In some States a commercial vehicle is held to be any vehicle used for carrying freight or articles of commerce, while in others only those vehicles used for hire are classed as commercial.

The amount of fees collected per car for either pleasure or commercial vehicles is as yet far from uniform and is still further complicated by the widely varying requirements for the registration or licensing of chauffers, owner operators, dealers, etc. Thus, if the total gross registration and license revenues be used as a basis of revenue, and the total automobile trucks and vehicles as the basis for motor cars, it is found that for the entire United States the average fee per car was $7.62. On the same basis the State of New Hampshire received in 1917 a gross revenue of $19.10 for each motor car, while Minnesota received only about 50 cents annually for each car, as the registration in that State is for a three-year period.

In most States motor cars are taxed as personal property in addition to the required registration fees. In Alabama, Delaware, Idaho, Iowa, Michigan, New York, North Dakota, Okalahoma, Pennsylvania, Vermont, and West Virginia the registration fees are in lieu of all other taxes. Therefore, in making any comparison of fees as between the several States this fact should be borne in mind.

The registrations of automobiles, motor trucks, commercial vehicles, chauffeurs and operators, dealers, and manufacturers are the total gross registration and license revenues and the amount of this available for road work either by or under the State highway department or local subdivision for the year 1917 is given in Table 1. The number of registrations given in this table do not necessarily indicate the exact number of motor vehicles of any one or of all of the several classes in actual use or existence in the several States except so far as the laws of the several States require and enforce an annual registration under these classifications. However, as all the States with the exception of Minnesota and Mississippi now require annual State registrations, these furnish a very definite index of the total number of cars in existence. But many States make distinction so far as the registration laws are concerned between pleasure cars and commercial vehicles. Hence, the column headed "Motor trucks and commercial vehicles" does not show the total number of such vehicles except in some States. Reference to the principal requirements in the registration of motor vehicles which are charted in Table 4 will serve to make clear what the data in Table 1 represents.

Table 2 gives a comparison of the motor-car registrations and total revenues for the years 1913 to 1917, inclusive. For further information in regard to registrations and revenues previous to 1913 the reader is referred to Office of Public Roads Bulletin No. 48, "The Repair and Maintenance of Highways," pages 68–71.

RECORD IN CROSSING ELIMINATION.

District No. 4 has received a project statement in Iowa County, Wis., from the Wisconsin Highway Department, the principal feature being that it will eliminate, so far as the project is concerned, 10 railroad grade crossings in 8.66 miles. This is believed to be the record so far in this district in the number of crossings eliminated on any one project or so short a mileage.

The proceeds of the Liberty Loan, including the greater part of that loaned to our Allies, are being spent for American products—the products of our factories, our farms, our mines, and other industries. In lending to the United States the people of the United States are lending to their best and largest customer.

BUY LIBERTY BONDS

CLEARING ROADS FOR ARMY TRANSPORT.

THIS is the story of how the Pennsylvania State Highway Commission, under the direction of J. Denny O'Neil, State highway commissioner, planned early last fall to cooperate to the fullest extent possible with the Federal Government, so that the movement of United States Army transport trains from the West to the seaboard could be made over Pennsylvania's State highways in a speedy and safe manner.

The main highway, over which passes a large portion of interstate traffic, extends from the Ohio State line, through Beaver Falls, Pittsburgh, Greensburg, Bedford, McConnellsburg, Chambersburg, Gettysburg, and Littlestown, to the Maryland State line, a distance of about 225 miles, and runs through mountainous regions. Commissioner O'Neil realized that snow-removal work would enter largely into the success of the project and plans were laid accordingly. George H. Biles, second deputy State highway commissioner, who is in direct charge of all maintenance work on the Pennsylvania State Highway System, devised a system for the effective removal of snow.

In describing the methods used Deputy Commissioner Biles says:

By GEORGE H. BILES.

A system of operation for handling this work was established by the maintenance division of the State highway department, which will be described briefly:

Through arrangements made with the Weather Bureau office at Pittsburgh, weather forecasts were wired to the main office of the State highway department, by which conditions could be anticipated and instructions issued immediately to the various districts to organize men and equipment for action. The field organization of the State highway department consists of the assistant engineer, who has control of all work in a number of counties—usually about five—followed by the superintendent of highways of the county, who has charge of all maintenance work; under the men come the gang foremen, patrolmen, laborers, etc. This organization had complete charge of this work in their respective counties and is under the direction of the second deputy commissioner, in charge of maintenance.

Stationed at the larger towns along the line of this route were motor trucks equipped with snowplow, attachments, road machines, drags, shovels, etc. The patrol system of about 34 men was engaged continuously in repairing and patroling this highway, each man looking after his particular section, and this plan was a most important factor in reporting emergency conditions of consequence to the district head, or superintendent, who reported by wire or phone to the main office directly. The caretaker was empowered to organize forces, if need be, to take care of conditions until the arrival of the superintendent. If conditions were unusual, the superintendent reported by phone to the assistant engineer, who arranged to inspect and handle the work accordingly.

The report made by the caretaker was either by wire or telephone, and was followed by a postal-card report form, giving details, and addressed to the main office at Harrisburg. This information was charted as soon as received and the same practice followed upon the completion of the work. If the drifts were abnormal and the road not opened within 24 hours the office had to be advised by wire, and in this way headquarters was in direct touch with and control of the entire route at all times.

The first snowstorm of consequence occurred on December 7 and 8 and was general over the entire route. For many miles drifts averaged 3 and 6 feet in depth. The work was begun by breaking a track through the drifts with teams and drags. This was followed by road machines, or trucks, with the plow attachments, and shovelers. Turnouts were made along the line, and thereafter the road was widened out to a width of between 14 and 16 feet, depending upon the location. The entire travelable width of the roadway was opened finally in order that traffic would not track and cut through the road surface during periods of freezing and thawing. The snow was removed at first to within 3 inches of the road surface and what did not melt was afterward removed entirely. After a track was broken through the deep cuts it was necessary to resort to shoveling.

As soon as any section of the road was opened, shovelers followed, cutting openings from the side to the ditches at various intervals along the road. When this work was completed the road was again turned over to the caretaker, or patrolman, to look after drainage details.

From observations taken since 1913 it had been found that at certain locations the construction of snow fence would be advantageous and economical, and while it was impossible to get all of the necessary fence in place this season some of it had been constructed, and before another season arrives the remaining sections will be provided for.

There were certain sections along the line of the route where it became necessary to work night and day shifts, and after the organization had been perfected each succeeding storm was handled with increased celerity and efficiency.

In the beginning the work was handled with the following organization and equipment, which was augmented from time to time: Seven motor trucks and plows, 22 road machines, 20 drags, 105 teams, 3 tractors, and 200 men."

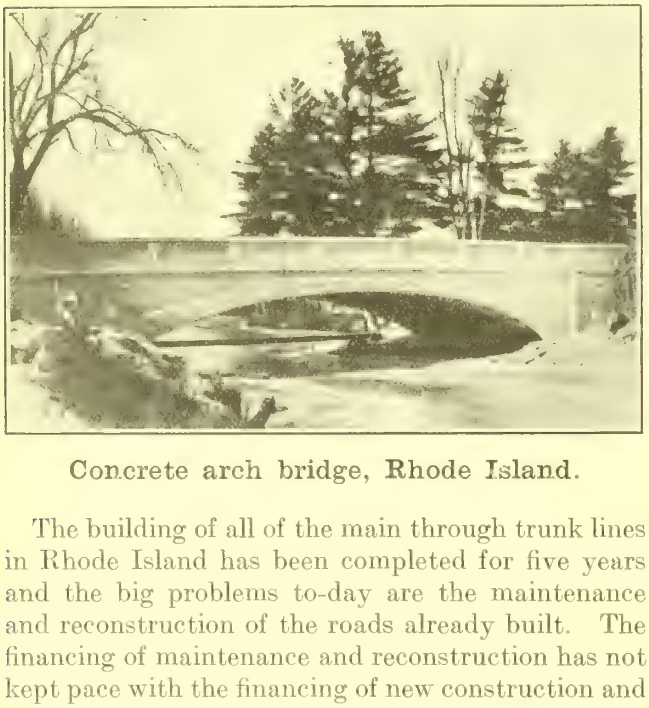
MAINTENANCE IS RHODE ISLAND'S BIG PROBLEM.

State Confronted by Fact that Many of Earlier Built Roads Can Not Stand Present-Day Traffic.

By

I. W. PATTERSON, Chief Engineer, Rhode Island.

STATE road building in Rhode Island is under the control of the State board of public roads, which body is made up of five men, one from each of the five counties of the State. The term of one of the board members expires each year and appointments are made for a term of five years. Appointments to the board are made by the governor with the advice and consent of the senate. The legislative act creating the board was passed in 1902 and the actual building of roads under the act was begun in 1903. Since that time the building and maintenance of State roads has continued uninterruptedly.



Concrete arch bridge, Rhode Island.

The building of all of the main through trunk lines in Rhode Island has been completed for five years and the big problems to-day are the maintenance and reconstruction of the roads already built. The financing of maintenance and reconstruction has not kept pace with the financing of new construction and in consequence we are confronted by the fact that a great many of our earlier built roads are not in condition adequately to withstand the travel passing over them to-day.

The traffic to which the State roads of Rhode Island are subjected is severe. This State is essentially a manufacturing community and for this reason our State roads are called upon to carry a heavy commercial travel during the entire 12 months of each year. The presence of a large number of popular shore resorts in our State involves also a very heavy motor tourist traffic during the summer months.

We have not employed a large number of types of construction in the building of our State highways. Water-bound macadam, bituminous macadam, and bituminous concrete are the only types built to date. For the first three years that State roads were built in Rhode Island water-bound macadam was employed exclusively. In 1906 an experiment with bituminous concrete was carried out successfully, but this type was not built to any considerable extent until 1909. Since 1913 no water-bound macadam has been built. One of the chief obstacles to the success of water-bound macadam in this State is the absence of good road building stone in many sections so isolated from railroad facilities that in the earlier days of road building the importing of stone was deemed prohibitive. There are a number of sections where the only stone available is granite, which is so badly decomposed as to be of very little value for road building, and yet there are many miles built of this material. Until motor travel became heavy much of the road built of this inferior rock gave very good satisfaction, but of late years the task of maintaining these roads is almost hopeless.

The first use of bituminous binders in State road work was by the cold hand-mixing method, employing crusher-run stone from ½ inch to 1½ inches for the mineral aggregate. During the years from 1906 to 1913, inclusive, approximately 80 miles of road was constructed by this method. The details of construction varied considerably during this period and many different types of bituminous binders were employed. Machine mixing did away with hand mixing to some extent during the latter part of the period in which roads of this type were built.

Upon the whole, our mixed roads have proved satisfactory. Processes and materials employed or selected by way of experiment occasionally proved of little value and were the direct cause of failure in several instances. Practically all of these roads are, however, still taking care of the travel which passes over them in a very satisfactory manner.

Since 1913 the use of bitumens as binders has been confined to the construction of bituminous macadam by the penetration method, with very few exceptions. The details of this construction and the types

Reverse curve on a Rhode Island highway, showing one-way slopes on curves.

of binders employed have varied but slightly. The use of crushed stone screened to comparatively large and uniform sizes, the employment of a heavy binder at a rate per square yard of at least 2½ gallons, particular attention to rolling and careful treatment of subsoil difficulties have characterized this work. The results secured by the pentetration method have been more satisfactory upon the whole than were the results secured by the mixing method as we employed it in our earlier work. We appreciate, of course, the fact that our mixing work was greatly handicapped by the use of an aggregate which was not well graded as to sizes.

The conditions affecting the design and construction of roads in Rhode Island are considerably diversified in spite of the fact that our State is diminutive in size. There are sections of the State where subsoil difficulties do not exist because of the presence exclusively of sand or gravel. There are, upon the other hand, sections where a heavy clayey soil very much subject to frost action is found to the exclusion of all other soils. Certain sections of the State, furthermore, offer variety of subsoil characteristics, alternate streaks of freely permeable soil and of heavy retentive soil occurring at short intervals. Excavation is made very difficult in a number of localities because of the presence of bowlders in great numbers, varying in size from one-man stones to stones weighing from 10 to 25 tons. We have no mountainous section to contend with, but we have in the entire western section of the State a hilly region which offers more or less difficulty in highway location as compared with the difficulties encountered in the eastern portion of the State.

Previous to 1912 the bridges located upon State highways were under the control of the towns in which they lay. In 1912 these bridges were placed under the control of this department. Few of the bridges at that time were in good repair and many were in dangerous condition. The work of replacing the weak structures was begun at once and has been continued without interruption since that time.

We do not employ standard designs of bridges. The number of bridges for which we are responsible and the small size of our State makes desirable to our minds the treating of each bridge as a problem by itself and the designing of each structure independently.

The principal developments in the bridge department during the past season are the introduction of force account for the construction of bridges, the elimination of centering and saving of material in a modified type of girder bridge, the innovation of split piles devised for the solution of special foundation problems, the incorporation into designs

President Wilson looks to the toil, intelligence, energy, foresight, and patriotism of the American farmer to win this war.

BUY LIBERTY BONDS

of a feature which allows increasing widths of bridges at a future time when traffic makes such a course necessary, the adoption of a new large-size test mold for compression tests of concrete, the use of portable steel office buildings, and the solution of a troublesome detail in the practical construction of circular balusters. The statement that the results obtained by the adoption of the above new features generally fulfilled our expectation may safely be made.

At the end of 1917, or the sixth construction season since the organization of our bridge department, more than half our bridges are of permanent construction. One bridge in every three is of concrete, 22 per cent stone, 18 per cent steel, and 27 per cent wood. Five wood bridges have been replaced with concrete this season and for the first time the number of concrete bridges on the system exceeds the number of wood structures. We now have a permanent bridge for every 4 miles of State highway.

The State pays the entire cost of building and maintaining of State roads. We have a State aid law which makes possible State aid for towns, but advantage has been taken of this law in only one instance since its passage seven years ago. There have been three bond issues for the building of State roads, the last of these having been made available in 1912. The money secured from the registration of motor vehicles is employed for the maintenance of State roads. Direct appropriations for State road work by the legislature have been frequent. The legislature meets annually in Rhode Island and it has always been the custom to take action in regard to the appropriation of funds for State road work at each session. Frequently appropriations are not made until April or May of the year in which it is purposed to spend the funds appropriated. It is apparent that this system of making appropriations imposes a hardship upon this department by seriously limiting the time available for preliminary work.

For the past two years we have had to spend in addition to the motor vehicle fund the proceeds of a State highway tax of 3 cents on each $100 of the ratable property of the towns and cities of the State. This tax has amounted to over $200,000 each year. Bridge work is financed separately from road work in Rhode Island.

STATUS OF HIGHWAY WORK IN WISCONSIN.

By

A. R. HIRST, State Highway Engineer.

HIGHWAY construction in Wisconsin is carried out under three distinct systems: First, the Federal aid construction, performed under the authority of the Federal aid road act and the State trunk highway law; second, the State aid construction, performed under the State aid law; and, lastly, the township construction, performed under the State statutes relating to this work. In the interest of strict accuracy, it may be well to say that actual construction under the Federal aid plan will not be begun until the season of 1918, and that the State highway commission is at present nearing the completion of the preliminary work necessary to undertaking actual construction.

The most important part of this preliminary work has been the selection of the State trunk highway system, authorized under the State trunk highway law. Under the law this system must not exceed 5,000 miles and must interconnect all county seats and cities with a population of 5,000 or more. The selection of the system is a duty of the State highway commission, but the statute provides for a special legislative committee consisting of five members, appointed by the governor, to whom appeals from the selection of the commission may be taken. It is provided that in counties where the commission felt there was special difficulty in the selection of the system the legislative committee might be invited to hold a joint session at the county seat, and the selection thus made jointly be final.

Under the law all construction with State and Federal aid must be confined to this trunk highway system. The Federal law requires that the State must provide an amount at least equal to the Federal aid allotted to the State. The State law requires that the county in which construction is done shall provide an amount equal to one-half of the sum of the joint State and Federal allotments. All construction costs thus will be borne in the proportion of one-third by each of the units concerned. The joint State and Federal funds are apportioned to the counties, one-third on the basis of area, one-third on the basis of valuation, and one-third on the basis of total road mileage. Provision for the State's share

In the organized might of this Republic every American has a place, a station, and a duty. Some fight; others must work, save, and give financial support to the Government.

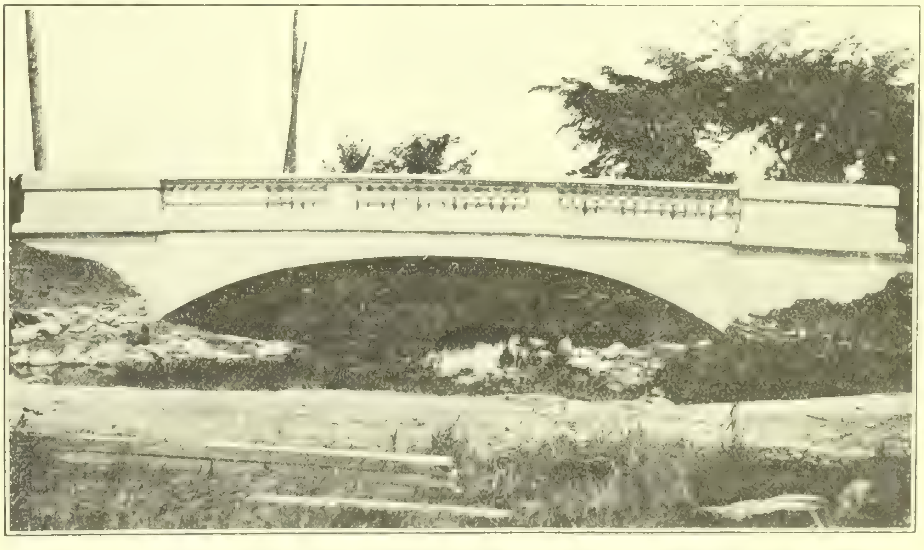
of the cost of Federal aid construction is made from the proceeds of the automobile license fees, which have been increased to $10 for ordinary cars, with trucks licensed at rates from $15 to $25, depending upon capacity. The net proceeds of automobile licenses are to be expended in the following manner:

A stretch of Wisconsin's State Highway System.

1. One-fourth to the counties in proportion to the amounts paid in.
2. A sum not to exceed $80,000 is then allotted to the State highway commission for the administration of the State trunk highway law.
3. The amount necessary for the State's share of Federal aid construction funds is then allotted for that purpose.
4. The remainder is then apportioned for maintenance and distributed among the counties in proportion to the State trunk highway mileage in the county.

The State highway commission is charged by law with designation of the location of improvements. There need not be construction in each county each year, but at the end of the three-year period contemplated by the law each county must receive the full amount allotted. Under the authority thus conferred the State highway commission has designated improvements in 57 counties. These improvements have been selected with a view of serving the greatest public interest and have been placed on the worst portions of important roads where there is but little prospect of securing the improvement through local initiative. The improvements projected aggregate approximately 190 miles of earth roads, 70 miles of gravel surfacing, 20 miles of stone macadam, and 45 miles of concrete or brick pavement, a total of 325 miles. The total estimated cost is approximately $2,000,000. The completion of these projects will mean the improvement of the worst spots on the system, and the improvement of the entire system by the improvement of its poorest portions.

As stated financial provision for the maintenance of the State trunk highway system is made through the proceeds of automobile license fees. The law provides that the maintenance shall be carried out by the counties under the supervision of the State highway commission. The greatest weakness of the State highway work as done heretofore has been inadequate maintenance. It is the intention to establish a maintenance system under the new law as adequate as the financial provision therefor will permit and by this means to keep the entire system in good condition all the time. The commission is now making a study of the best methods of accomplishing this result, and it may be said that it is the intention to improve a large mileage of roads by blade grader work and to keep these roads in passable condition as far as can be done by systematic dragging. Surfaced roads will be maintained by the method appropriate to each particular type. The work will be done by a combination of the gang and



One of Wisconsin's 1,500 State aid bridges.

patrol systems; where the work is of such a nature as to require more than one or two men, a force equipped with proper machinery will be utilized; where reasonably possible the maintenance work will be executed by one patrolman with additional assistance only when necessary through some unusual condition.

The best estimates which can be made at this time indicate that there will be available about $875,000 for this work in 1918, which provides $175 for each mile on the trunk highway system. It is not contended that this amount is fully adequate, but it is certain that the results which will be secured will far surpass anything done heretofore in Wisconsin.

Another important duty of the State highway commission under the State trunk highway law is to mark the roads on the State trunk highway system. The law provides that after the system has been finally selected, the commission shall cause the various roads comprising the system to be marked distinctly with some standard design which shall be uniform throughout the State, except that numbers occurring thereon shall correspond to the numbers given the various roads by the commission which shall coincide with the numbers placed on the commission's official maps. This map shall be published in the spring of 1918 and as often thereafter as necessary. The commission is required also to erect such standard guide and warning signs as may be deemed necessary.

This task is one of great magnitude and importance and will require much pioneer work. A study of the most practical and feasible method of accomplishing the desired results which are to give the traveling public a maximum of information with a minimum of confusion is now under way.

The State-aid system has been in effect since July, 1911, and construction under its provisions has been carried out during the seasons of 1912 to 1917, inclusive. Since its original enactment this law has been amended in some of its details by each legislature, but the basic plan of the law has remained unchanged though there has been a constant tendency toward a concentration of improvements on the main lines of travel. Originally any town might initiate an improvement and be certain of receiving a like appropriation from the county and to participate in the distribution of the State highway fund. As might be expected this plan resulted in a scattering of the work which was not to the best interests of the work itself, considered purely from a construction standpoint. But it did have a very great educational influence. People who never had seen properly improved highways and who had no idea of what an improved highway might be like, had these improvements brought to their very door, and having thus learned the value of properly improved roads, forthwith desired more of the same kind. The result is that the people of the State have been educated to an appreciation of the value of highway improvement, without which any very far reaching program would have been impossible and prepared for larger undertakings under both the State aid and Federal aid laws.

Are our hearts with our soldiers? The response to the Third Liberty Loan will be the answer.

As the law now stands, the State provides an appropriation of $785,000 per year, which is allotted to the counties in proportion to their assessed valuation. To receive this money the counties must raise certain amounts by county appropriation, and assess certain taxes against their municipalities, as hereafter explained. One-half of the allotment to each county, together with one and one-half times this amount, provided by the county, must be spent in improvements on the State trunk highway system at points designated by the county boards. The remaining one-half of the counties' State aid allotment then is distributed among these towns, villages, and cities of the county, which are unbenefited by a State trunk highway system improvement the same year, in proportion to their assessed valuation. A county appropriation is made at least equal to the State money allotted to the municipalities, and a tax not less than the State money nor greater than the county appropriation is levied against each municipality. It will thus be seen that the cost of State aid improvements made jointly by the State and a county is born 40 per cent by the county and 60 per cent by the State, and the cost of improvements made by the State, a county, and a municipality is borne one-third by each. The State percentages given are maximum, the counties may raise amounts greater than the minimum required to claim the State aid, thus reducing the State's percentage.

All improvements made under the State aid law must be made on the county system of prospective State highways at locations designated by the county board and approved by the State highway commission. The actual execution of the work is by the county highway commissioner and his forces working under a county State road and bridge committee. The entire work is under the supervision and direction of the State highway commission and must be carried out in accordance with its plans and regulations and the terms of the law.

The average annual cost of all road and bridge construction under the provision of this act has been approximately three and one-fourth millions of dollars ever since the enactment of the law. The result has been the improvement of approximately

(Continued on page 38.)

ROADS PIERCE ALASKAN WILDERNESS.

Less Than Dozen Miles Have Become 980, While Trail Mileage Has Passed 2,000.

By

CAPT. W. H. WAUGH, President Board of Road Commissioners.

Typical Alaska wagon road, Gastineau Channel.

The Board of Road Commissioners for Alaska, constituted by act of Congress in 1905, and composed of three officers of the Army, has been in existence for 13 years. The board was heralded by a demand throughout the 600,000 square miles of the Territory for immediate results. The magnitude of the problem, coupled with the great variety of unusual difficulties, was not encouraging.

There presented itself a great wilderness (ten times the area of the State of Wisconsin) untracked for the most part by the foot of the white man, broken and rugged in many parts, heavily timbered and with a dense undergrowth in the coastal belt, underlaid throughout most of the valleys of the interior with permanent frost to a great depth protected by a thick blanket of moss, with the whole area buried under snow for many months of the year, and in summer intersected by numerous deep, swift, and changing streams fed by the melting glaciers and snows of the mountains. Throughout the Territory there existed less than a dozen miles of wagon road, with a few hundred miles of pioneer trail, most of which was constructed by various expeditions under the War Department.

The population consists chiefly of miners, fishermen, lumbermen, and a very few homesteaders, scattered along the coast of southeastern Alaska and through the interior, separated in most cases by great distances, with but little common interest, all needing and demanding roads, but giving little thought to the fact that it required much money to build roads, and time to perform the work.

The board has constructed 980 miles of wagon road, 623 miles of sled road, and 2,291 miles of trail, and has expended for all purposes to June 30, 1917, a total of $3,969,611, of which sum $2,265,000 has been appropriated by Congress and $1,704,611 from Alaska.

Brig. Gen. W. P. Richardson, who will always be known as the pioneer road builder of Alaska, has been president of the board from its organization until December, 1917, when he was placed in command of a brigade in the National Army. The present board is composed of Capt. W. H. Waugh, president and engineer officer; Capt. John Zug, assistant engineer officer; and First Lieut. Sidney L. Carter, disbursing officer, all being commissioned in the United States Engineer Reserves.

The Office of Public Roads and Rural Engineering is now making a location survey and expects to start their Alaska highway work in the Tongass and Chugach National Forests in 1918. F. A. Kittredge, highway engineer, has made the location surveys in southeast Alaska and construction will be undertaken as soon as the season opens in the spring. This work is handled through the district engineer, Portland, Oreg., by Capt. Waugh, in cooperation with the Territorial Road Commission. Ninety-three thousand dollars is now available for roads within the national forest reserves and an additional $46,000 becomes available July 1 each year until 1925.

Building Grade Auke Bay Road near Juneau, Alaska.

A third highway organization is the Territorial Board of Road Commissioners, comprised of the governor of the Territory, the surveyor general, and the Territorial treasurer. The Territory is divided into four Territorial road divisions in charge of the divisional road commissioners. The divisional road commission is composed of an elected chairman and two members appointed by the governor. These officers serve for two years. Fifty thousand dollars is appropriated annually for each division.

MICHIGAN TOUCHES HIGH POINT IN CONSTRUCTION.

By

FRANK P. ROGERS, State Highway Commissioner.

Twenty per cent of the entire mileage of roads built in the 12 years since the State reward law became operative was constructed in the year ended June 30, 1917. In that year 1,052.8 miles were built and $1,241,306 State reward paid. The rapid increase in road building is shown by the accompanying table.

Indications are that a smaller mileage will be constructed in the fiscal year 1918, largely, of course, on account of the war conditions. The first six months of this year show a falling off of about 30 per cent as compared with the same period last year.

Fiscal year.	Miles built.	Reward paid.
1906	18.1	$13,675
1907	64.4	51,701
1908	96.4	71,729
1909	162.2	117,021
1910	204.4	137,327
1911	304.2	193,876
1912	382.6	249,671
1913	522.0	329,392
1914	682.3	581,736
1915	759.8	783,566
1916	744.6	757,532
1917	1,052.8	1,241,306
Total	4,993.8	4,528,532

The State reward law became operative July 1, 1905. It created the State highway department and provided for the payment of rewards ranging from $250 to $1,000 per mile on roads which were to be built under State specifications. These roads were to have a metal surface not less than 9 feet in width and a turnpike not less than 18 feet in width. At that time no provision was made for an increase of reward on roads having a greater width of metal surface. The law has been amended more or less by every succeeding legislature and rewards at present range from $250 a mile for a single track, sand-clay road to $8,400 a mile for roads having a metal surface 20 feet in width, when built on trunk line routes and of such materials as concrete, brick, or asphaltic concrete.

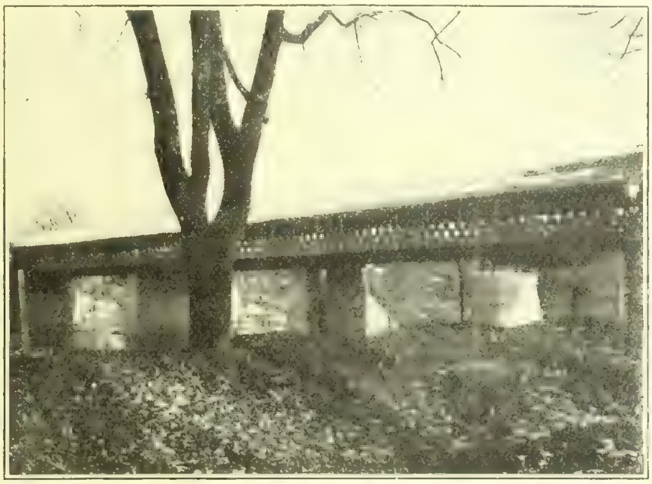
The legislature of 1913 passed the trunk-line highway act, providing for the establishment of approximately 5,000 miles of trunk lines in the State, which were defined in a general way by naming the cities and towns to be connected by this system of roads, but leaving to the local authorities and the State highway commissioner the power to determine the exact routes to be followed. This law provided that trunk-line routes were to receive twice as much reward as had been paid formerly on State reward roads or would be paid hereafter on roads not on the trunk lines. It was provided further that all bridges of more than 30 feet clear span on the trunk lines should be designed, built and maintained by the State, provided the township or county build three or more miles of road, including the bridge site.

The construction of bridges by the State, together with the payment of double the amount of ordinary State reward on road construction, has done much to hasten the improvement of these main roads. Many communities that have been able to improve their trunk-line roads would have found it practically impossible without this additional aid. Up to January 1, 1918, the State has expended $562,830.45 on the construction and

Victory does not depend solely on our fighting men; it depends on all Americans. Work, save, and lend to the Government.

maintenance of trunk-line bridges. Seventy-six new bridges have been built and 14 existing structures have been repaired temporarily in such manner as will make them adequate for several years. Thirteen new bridges now are under construction.

The 1915 legislature passed the assessment district act, commonly called the Covert Act, by which road improvement could be initiated on a petition signed by a majority of the frontage on any given road not less than two miles in length, thus making it possible to improve the road by spreading a portion of the cost on an assessment district, somewhat similar to a drainage district, the remainder of the cost being paid by the townships and counties in which the road lies or which are especially benefited by reason of the improvement. A provision also was included making it possible to sell bonds for the improvement and extend the period of payment over from 1 to 10 years.



Old covered wooden bridge replaced with modern steel truss type of construction by Michigan State Highway Department.

Under this act 204 petitions, aggregating 1,070 miles, which probably will cost more than $7,000,000, have been filed with the State highway commissioner.

Until the law was amended by the 1917 legislature and declared valid by the supreme court the State highway department found it impossible to sell bonds. The supreme court handed down a favorable decision the latter part of July, 1917, and since that time 11 roads, aggregating 64½ miles, have been placed under contract at a total cost of $445,340. On all of these roads bonds have been sold for all but the first year's assessment. If no serious difficulties are encountered in the way of letting contracts it is highly probable that during the summer of 1918 the State highway department will have in process of construction under the Covert Act more than 200 miles of road.

The foregoing gives a general summary of the activities of the State highway department. A great deal has been accomplished looking toward the completion of the trunk-line system in the State, and with the help of Federal money, which will be available, it is expected that a few more years will see these main roads practically completed.

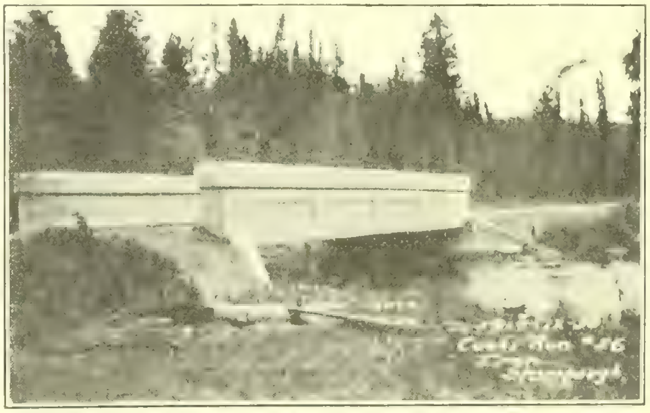
Bridge construction has been one of the most important features of the work of the department for the last four years, and much has been done to study local conditions and work out the best methods in design and construction. Standard designs have been prepared for several different types of structures. Up to within a year ago the low steel truss with a reinforced concrete floor was used quite commonly. In building these the department has adopted the plan of pouring one-half of the floor at a time so as to interfere with traffic during construction as little as possible.

Many old and inadequate bridges have been replaced by the department with well-built, modern structures, capable of carrying a moving load of 18 tons.

An interesting type of covered bridge erected a number of years ago has been replaced recently with a four-span low truss.

Under present conditions the reinforced concrete girder is used most widely on account of the relatively low cost of construction and the adaptability of the design to conditions encountered. A typical view is shown of a single-span girder built by the department in one of the upper peninsula counties.

Another problem of increasing importance is the matter of elimination of railroad crossings at grade. In laying out State trunk lines such crossings have been avoided wherever possible. In numerous instances dangerous crossings have been avoided by making new locations by purchasing new rights of way, the cost of which were insignificant in comparison with the benefits derived.



Reinforced concrete girder bridge built by the Michigan State Highway Department in Stambaugh Township, Iron County, Upper Peninsula.

A number of grade separations have been made throughout the State at considerable expense. The most important of these in which the State is involved is located on the trunk line, about 1 mile north of the city of Ann Arbor, crossing the tracks of the main line of the Michigan Central Railroad between Detroit and Chicago. In this separation two structures were necessary, one over the railroad and one to the north over the Huron River. An earth fill is being constructed between the two structures and at each approach. The total cost of the two structures and earth fill will be about $80,000, and it is expected they will be completed ready for travel early this coming summer.

SOUTH CAROLINA WILL CONTINUE CONSTRUCTION.

By

C. O. HEARON. Member State Commission.

Although South Carolina's State Highway Commission is only a year old, it has completed the organization of its two branches, laid out a system of State roads, and taken steps to provide for aid to counties in building a number of necessary large bridges. The commission was authorized under an act approved February 20, 1917, and directs the highway department, which, in turn, is composed of two divisions—engineering and automobile licenses and registration.

Under the provisions of the State highway act 80 per cent of the fees collected by the last-named division are returned to the counties from which they are collected to be expended by the local authorities on roads and bridges; the remaining 20 per cent is deposited with the State treasurer as an operating fund for the State highway department.

The commission has been handicapped somewhat in its work due to the calling into national service of a number of officials and members of our organization, thirteen of whom are now serving their country in the present crisis.

Primarily the object for which the State highway department was created is to cooperate with the local road authorities in the counties of the State and to advise with them whenever so requested in the preparing of plans and specifications for their road and bridge work, and also to comply with requirements and conditions of the Federal aid road act, so that the State might secure its apportionment of the Federal aid funds for road and bridge construction.

The first work done was to appoint a State highway engineer, secure offices and office equipment, purchse automobile license plates, and organize an office force; consequently the office was not actually in working order until about the 15th of April. The commission then proceeded with the organizing of the engineering division and the preparing of necessary forms and blanks, specifications and standards for road and bridge construction. In this work it was assisted materially by the United States Office of Public Roads.

Prior to the organization of this department there was no systematic plan for the development of a State system of highways. The only work that had been done up to that time was by a few counties with bond issues or special taxes, each working according to its own plans without respect in most cases to a connected State system.

The first work of the department was to outline and prepare a map of the proposed system of State roads. This system was designed so as to facilitate communication between the important market centers and various county seats, and at the same time afford through lines of communication between adjoining States. It is not expected that the proposed system as outlined can be entirely completed with Federal aid funds apportioned to this State, but it is hoped that the counties will continue the work of constructing this system until it is finally completed. There are two main north and south highways through the State, one known as the National Highway, which passes through the western part of the State, and the Washington-Atlanta Highway, which passes through the eastern portion of the State. Federal aid projects have been approved for work on sections of both of these highways, and it is the hope of the commission that with the assistance of Federal aid both of these highways will be improved eventually, so they will be in condition for through traffic at all seasons of the year.

Investigations have shown that the proposed State highway system, as mapped out by the commission will be incomplete without the construction of several large bridges over the main rivers of the State. In view of the fact that the magnitude of these projects is such that the county or counties adjacent thereto could not possibly finance them without assistance from the State, the commission has recommended that present State highway act be amended to provide that 50 per cent of the amounts required to be returned to the counties from the automobile license fees under the present act be set aside each year for the next five years to form a State bridge fund, to be used in the construction of these proposed bridges under the supervision of the State highway department, the remaining 50 per cent to be returned to the counties to be used as specified by the act.

It is not expected that the lack of transportation facilities at the present time will seriously affect the 1918 road-building program for the State. Three out of four of the projects which will require rail shipments of material are for roads leading to the three national cantonments in the State. These roads are of vital importance to the operation of these camps, and we have been assured that material for the construction of these roads can be shipped as material for Government use. With the exception of some prospective bridge construction, the remaining projects will be sand-clay, top-soil, or local gravel construction which will require no rail shipments.

EIGHTEEN MONTHS OF FEDERAL AID.

LEADERS IN FEDERAL AID.

First State to submit project under Federal aid act	California
First State to complete construction of project	California
Leading State in number of projects submitted	Texas
Leading State in number of miles of proposed improvement	Texas
Leading State in estimated expenditure on improvement	Ohio
Leading State in amount of Federal aid asked	Texas
State submitting greatest mileage in single project	Illinois

APPROXIMATELY 18 months have elapsed since the beginning of actual progress under the Federal Aid road act, approved July 11, 1916. California has the distinction of having filed the first project statement, that having been one of five submitted on September 1, 1916. California also has the distinction of having completed the first Federal aid project, No. 3, on May 9, 1917. This was 2.55 miles of concrete construction in Contra Costa County, which cost $54,723.66, upon which there was paid $24,244.56 of Federal aid.

Up to and including February 28, 1918, there was a total of 383 project statements submitted, of which 265 have been approved, 6 disapproved, 3 canceled, and 4 withdrawn. Plans, specifications, and estimates have been approved to the number of 86. The total mileage covered by these projects was 4,453.66 and the total estimated cost $28,164,672.77, of which the States asked the Federal Government to assume the payment of $11,129,815.69.

In the number of projects submitted Texas leads with 36, for improvements in 29 counties. Of these 11 have been approved. Texas also leads in aggregate amount of Federal aid requested. The first project statement from that State was submitted on October 13, 1917, and the last on January 22, 1918. They describe improvements upon 494.69 miles of road at an estimated cost of $1,864,565.03, and Federal aid to the extent of $857,453.71 is asked. In 1917 Texas expended between eight and nine millions of dollars in construction, improvement, and maintenance on about 13,000 miles of road.

In number of projects filed Alabama is second to Texas, with 29 covering improvements in 28 counties.

Illinois has submitted a single project, but it is the longest in point of mileage of any submitted, being for 75.6 miles of concrete and bituminous macadam resurfacing of the Lincoln Highway to traverse Dupage, Kane, Dekalb, Ogle, Lee, and Whiteside Counties at a cost of $1,146,673.50. The State requests 50 per cent Federal aid. The next longest single project is one in Georgia of 73.85 miles of sand-clay or top soil to traverse Clayton, Henry, Spaulding, Pike, and Monroe Counties and to cost $180,630.72, of which the Government is asked to assume half.

Ohio has submitted 12 projects, aggregating some 68.62 miles, but the estimated cost is $2,201,757.26, and the Federal aid requested $651,080. It is noticeable that this entire proposed construction is of either concrete or brick, with two exceptions, one being of 4.48 miles with optional macadam or concrete construction, and another of 5 miles with optional bituminous macadam or brick. Ohio leads the States in estimated cost of improvements to be undertaken.

Kansas has come forward with three projects which cover 82 miles of construction upon which it proposes to expend $1,635,532.49 and requests only $245,329.87 of Federal aid.

The Central States in general have laid out fairly extensive programs. Michigan has filed 15 statements, of which 12 have been approved. Plans call for improvement of 141.25 miles at an estimated cost of $1,185,717.11, for which the State asks $603,978.54 of Federal aid. Gravel construction predominates largely, although the longest project—42.86 miles—is of graded earth.

Fourteen projects, of which 11 have been approved, have come from Iowa. They call for the improvement of 239.56 miles of road at an estimated cost of $1,034,525.28, toward which the Federal Government is asked to contribute $318,373.50. Proposed improvements are largely graded earth and gravel. Of the 14 project statements filed by Minnesota, 13 have been approved and 1 withdrawn. Improvements are contemplated on 268.42 miles of road, upon which it is planned to expend $781,673.41, with $358,742.18 of it in the form of Federal aid. Considerably more than three-fourths of the improvements are of gravel, the longest project of this type being for 50 miles.

Among the Southern States there has been considerable activity.

Every step taken by the respective States under the Federal aid act is covered in the following tables.

RECORD OF FEDERAL AID, TO MARCH 1, 1918.

State.	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
Ala.	1	Mar. 7, 1917	Aug. 18, 1917	Oct. 13, 1917	Montgomery-Union Springs Road.	Bullock	8.83	Sand-clay	$23,733.93	$11,866.96	$11,866.96
	2	June 15, 1917	Aug. 31, 1917	Oct. 17, 1917	Forest Highway	Escambia	9	do	20,042.06	10,021.03	10,021.03
	3	June 9, 1917	do	do	Ozark, Troy, and Montgomery Road.	Pike	9.11	do	20,662.73	10,331.36	10,331.36
	4	do	Sept. 4, 1917	do	do	Dale	8.71	do	20,064.58	10,000.00	10,032.29
	5	June 15, 1917	Sept. 18, 1917	Nov. 3, 1917	Telegraph Road	Mobile	7.1	Clay-gravel	19,965.00	9,982.50	9,982.50
	6	do	Aug. 31, 1917	Nov. 5, 1917	Andalusia-Opp Road	Covington	7.67	Sand-clay	20,003.50	10,000.00	10,001.75
	7	do	(1)	...	Bay Minette and Daphne Road.	Baldwin	11	...	20,011.20	10,000.00	...
	8	June 26, 1917	Dec. 13, 1917	Dec. 31, 1917	Eufaula and Clayton Road.	Barbour	7	Sand-clay	20,353.38	10,176.69	10,000.00
	9	June 23, 1917	Aug. 31, 1917	Dec. 10, 1917	Columbus and Tuskegee Road.	Russell	7.18	do	22,055.90	11,027.95	11,027.95
	10	Dec. 18, 1917	Jan. 5, 1918	...	Greenville-Georgiana Road.	Butler	8.07	Sand-clay or topsoil.	27,071.65	13,535.82	...
	11	July 19, 1917	(2)	...	Peakes Trail	Lowndes	.75	Gravel	14,032.70	7,000.00	...
	12	do	(3)	...	Fort Deposit and Greenville Road.	do	2.05	...	6,029.60	3,000.00	...
	13	Aug. 4, 1917	Aug. 27, 1917	Nov. 14, 1917	Anniston and Lincoln Highway.	Calhoun	5.5	Chert	22,834.35	11,417.17	11,417.17
	14	Aug. 21, 1917	Oct. 17, 1917	...	Talladega-Truss Ferry-Lincoln Road.	Talladega	9.37	Chert and gravel.	26,370.33	11,866.65	...
	15	Aug. 29, 1917	Sept. 7, 1917	Dec. 28, 1917	Dothan and Headland.	Houston	4.3	Sand-clay	21,665.44	10,832.72	10,832.72
	16	Aug. 21, 1917	Sept. 21, 1917	Dec. 4, 1917	Opelika-Loachapoka	Lee	11.31	Sand-clay and topsoil.	23,556.77	11,778.38	11,778.38
	17	Aug. 25, 1917	Sept. 17, 1917	Nov. 16, 1917	Eutaw-Tuscaloosa Road.	Greene	4.6	Clay-gravel	15,939.00	7,969.50	7,969.50
	18	Sept. 3, 1917	Nov. 16, 1917	...	Birmingham-Montgomery Road.	Jefferson	6	Bituminous macadam.	23,735.37	11,867.69	...
	19	do	do	Feb. 28, 1918	Attalla and Hokes Bluff Road.	Etowah	4.47	Slag and sand-clay; gravel treated with bituminous material.	17,992.40	8,996.20	8,996.20
	20	Sept. 8, 1917	Sept. 21, 1917	Dec. 6, 1917	Quenelda Road	Clay	2.5	Bituminous macadam.	21,564.10	10,782.05	10,782.05
	21	Sept. 24, 1917	Oct. 17, 1917	...	Linden and Demopolis Road.	Marengo	4.26	Gravel and sand-clay.	20,000.00	10,000.00	...
	22	do	do	Dec. 21, 1917	Jackson Highway	Colbert	6.79	Gravel, bituminous surface, and chert or slag macadam bit. surface.	23,425.73	11,712.86	11,712.86
	23	do	do	...	Between Elba and Troy	Coffee	9.34	Sand-clay	23,304.35	11,652.18	...
	24	Oct. 4, 1917	Oct. 20, 1917	...	Jasper-Birmingham Road.	Walker	4.5	Gravel	21,205.66	10,602.83	...
	25	Oct. 5, 1917	do	Dec. 28, 1917	North and South State Highway.	Morgan	9.18	Macadam	21,583.98	10,791.99	10,791.99
	26	Oct. 27, 1917	Dec. 5, 1917	...	Heflin-Anniston Road	Cleburne	3.5	Gravel	23,296.44	11,648.22	...
	27	Nov. 8, 1917	Nov. 22, 1917	...	Florence and Huntsville Highway.	Lauderdale.	5.91	Chert	32,432.12	11,999.88	...
	28	Nov. 10, 1917	Jan. 5, 1918	...	Turnpike Road	Coosa	5.8	Topsoil	19,994.12	9,997.06	...
	29	Nov. 12, 1917	Nov. 23, 1917	...	Tuscaloosa-Birmingham Road.	Tuscaloosa.	6.02	Gravel	19,885.25	9,942.62	...
Ariz.	1	Mar. 30, 1917	Apr. 25, 1917	Oct. 2, 1917	Bridge across Gila River.	Pinal	1.02	Approaches to be gravel surface treated with oil.	115,799.79	55,749.70	57,899.89
Ark.	1	Mar. 31, 1917	Sept. 4, 1917	Oct. 10, 1917	Eureka Springs-Seligman Road.	Carroll	3.11	Gravel	11,891.88	5,945.77	5,945.77
	2	July 5, 1917	July 16, 1917	Sept. 13, 1917	Batesville Road and Mount Vernon Road.	Pulaski	5.5492	Warrenite surface on macadam base.	112,788.77	53,000.00	55,492.00
	3	Aug. 27, 1917	Sept. 15, 1917	Oct. 9, 1917	De Queen-Gilham Road	Sevier	7.95	Gravel	45,102.00	10,000.00	10,000.00
	4	Sept. 20, 1917	Oct. 4, 1917	Oct. 17, 1917	Garland City Road	Miller	5.994	Cementitious gravel.	34,883.09	17,441.52	17,441.52
	5	Sept. 24, 1917	Oct. 11, 1917	Nov. 20, 1917	Cache River Road	Lawrence	5.68	Gravel	29,541.49	11,590.86	11,590.86
	6	Sept. 29, 1917	do	do	"Walnut Ridge north to county line."	do	3	Macadam	8,596.76	2,500.00	2,500.00
	7	do	do	do	Fulton Road	Miller	2	Cementitious gravel.	12,397.67	2,558.48	2,558.48
	8	Nov. 19, 1917	Dec. 4, 1917	...	England-Keo Road	Lonoke	1.97	Macadam	8,871.72	3,169.00	...
	9	Nov. 24, 1917	...	...	Brinkley-Clarendon Road.	Monroe	8.08	Gravel; asphalt carpet coat.	74,943.66	37,471.83	...
	10	do	Dec. 10, 1917	...	Wynne-Memphis Road.	Cross	1.45	Gravel	4,532.15	2,266.07	...
	11	Dec. 3, 1917	Dec. 18, 1917	...	Cotton Plant-Des Arc Road.	Woodruff	2.99	Bituminous macadam.	22,459.69	10,000.00	...
	12	Dec. 31, 1917	Jan. 21, 1918	...	Wheatley and Bon Air Roads.	St. Francis.	7.6	Gravel	29,427.20	10,000.00	...
	13	do	...	...	Fishing Lake Road	do	4.94	do	26,180.00	5,467.10	...
Cal.	1	Sept. 1, 1916	Nov. 15, 1916	Mar. 29, 1917	Beresford to Redwood City.	San Mateo.	4.24	Portland cement concrete.	70,654.40	35,327.20	35,327.20
	2	do	(4)	...	Springville to Santa Clara River.	Ventura	5.63	do	57,361.68	26,150.84	...
	3	do	Oct. 18, 1916	Apr. 7, 1917	Alameda County line to Richmond.	Contra Costa	2.55	do	54,723.66	25,500.00	25,500.00
	4	do	(5)	...	Loleta to Beatrice	Humboldt.	4.3	do	37,334.00	18,667.00	...
	5	do	(4)	...	Roseville to Penryn	Placer	7.52	do	74,044.65	37,022.32	...
	7	Dec. 5, 1917	Dec. 22, 1917	...	Weaverville Road	Shasta	16	Graded and drained earth.	203,132.60	101,566.30	...
	8	do	do	...	Trinity River Road	Trinity	48	do	510,455.44	255,227.72	...
	9	do	Feb. 8, 1918	...	San Diego-El Centro Road.	San Diego	15	Concrete	373,010.00	150,000.00	...
Colo.	1	Oct. 10, 1916	Aug. 9, 1917	Nov. 28, 1917	Denver-Littleton Road.	Arapahoe	3.95	do	74,396.98	30,467.52	37,198.49
	2	July 21, 1917	...	...	Pueblo, Walsenburg, Trinidad, Raton Pass.	Huerfano and Las Animas	77	1 mile brick, balance gravel.	260,191.91	130,095.95	...
	3	Nov. 22, 1917	Jan. 29, 1918	...	Granite-Twin Lakes Road.	Lake and Chaffee.	11.94	...	37,089.80	18,544.90	...
	4	Aug. 4, 1917	Sept. 18, 1917	...	Rifle-Meeker Road	Garfield and Rio Blanco.	42	20 gravel or stone and balance earth.	79,082.85	39,541.43	...
	5	do	Dec. 27, 1917	...	Placerville-Norwood Road.	San Miguel.	2.99	Graded and drained earth.	7,480.00	3,740.00	...
	6	do	Sept. 18, 1917	...	Lamar-Springfield Road	Prowers	3.08	Gravel and shale.	10,030.90	5,015.45	...

[1] Withdrawn. [2] Disapproved. [3] Canceled. [4] Disapproved May 4, 1917. [5] Disapproved Nov. 15, 1916.

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State.	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length, in miles.	Type of construction.	Total estimated cost.	Federal aid requested	Federal aid allowed.
Colo. (con.).	7	Aug. 30, 1917	Nov. 28, 1917		Norwood-Naturita-Paradox Road.	Montrose	26	Graded and drained earth.	$29,999.20	$14,999.60	
	8	do	do		Meeker-Craig Highway.	Rio Blanco.	17.5	do	21,916.40	10,958.20	
Conn	1	Sept. 18, 1916	May 29, 1917	Oct. 13, 1917	New Haven-Cheshire Road.	New Haven	5.3	Concrete	148,691.01	53,000.00	$53,000.00
	2	Oct. 13, 1917	Oct. 25, 1917	Oct. 29, 1917	Groton-Norwich River Road.	New London.	2.54	do	69,275.25	25,400.00	
	3	Jan. 19, 1918			Norwich-Westerly Road	do	10.2	Bituminous macadam.	220,797.50	102,000.00	
Florida.	1	Aug. 7, 1917	Oct. 15, 1917		Old Spanish Trail	Okaloosa	10.31	Sand-clay	24,987.38	12,493.69	
	2	Oct. 29, 1917	Nov. 7, 1917		Kissimee-Loughman Road.	Osceola	4.12	Brick	67,233.22	20,000.00	
	3	Dec. 5, 1917	Jan. 9, 1918		Bridge	Jackson	[2]		105,013.31	52,506.65	
Georgia.	1	Nov. 6, 1916	Sept. 13, 1917		Atlanta-Macon Highway.	Clayton, Henry, Spalding, Pike, and Monroe.	73.85	Sand-clay or top soil.	180,630.72	[3] 90,315.36	
	3	Nov. 13, 1916	Oct. 20, 1917		Blue Springs Road	Brooks and Lowndes.	5.7	Sand-clay	56,045.22	28,022.61	
	4	Nov. 22, 1916	do		Monroe-Athens Road	Oconee and Walton.	11.1	Top soil	31,000.00	15,500.00	
	5	Mar. 25, 1917	Sept. 4, 1917		Alma-Waycross, Alma-Nichols.	Bacon	17.71	Sand-clay	30,193.02	[3] 15,096.51	
	6	Sept. 24, 1917	Oct. 20, 1917	Jan. 28, 1918	Brookton and Dahlonega Highway.	Hall and Lumpkin	8.47	do	37,728.90	17,214.45	18,864.45
Idaho	2	Oct. 1, 1917	Nov. 16, 1917		Lost River Highway	Custer	57	Graded earth gravel surface where needed most.	190,410.00	75,000.00	
Illinois.	1	Dec. 3, 1917	Dec. 17, 1917		Lincoln Highway	Dupage, Kane, Dekalb, Ogle, Lee, and Whiteside.	75.6	Concrete and bituminous macadam resurfacing.	1,116,673.50	[3] 573,336.75	
Indiana.	1	Dec. 26, 1917	Jan. 21, 1918		do	Elkhart	5.5	Brick, concrete, or bituminous concrete.	147,400.00	55,000.00	
	2	do	do		Main Market Highway.	St. Joseph	4.68	do	117,000.00	46,800.00	
	3	Jan. 22, 1918			National Old Trails Road.	Johnson	3.75	Brick or concrete.	99,435.00	37,500.00	
	4	do			do	Putnam and Hendricks	7.25	do	189,000.00	72,500.00	
	5	do			do	Wayne	1.5	do	47,300.00	15,000.00	
	6	Jan. 22, 1915			National Old Trails Road	Terre Haute, Clay, and Vigo.	3.75	Brick or concrete.	107,520.00	42,500.00	
	7	Jan. 24, 1918			National Old Trails Road, Madison Road, and Range Line Road	Marion	17.8	do	579,700.00	57,000.00	
	8	Feb. 9, 1918			Range Line Road	Hamilton	3.3	do	89,775.00	33,000.00	
Iowa	1	July 19, 1917	Aug. 10, 1917	Nov. 16, 1917	Mason City-Clear Lake Road, also known as North Iowa Pike.	Cerro Gordo	4.07	Concrete	99,541.81	22,453.75	22,453.75
	2	Aug. 8, 1917	Dec. 6, 1917		Sioux City-Denison Cut-off and Hawkeye Cut-off.	Woodbury.	54.75	1 mile concrete, 53.75 graded earth.	190,151.50	34,285.90	
	3	Oct. 20, 1917	Nov. 16, 1917		Blue Grass Road	Jefferson	20.5	Graded earth	41,123.20	16,830.55	
	4	Dec. 1, 1917	Jan. 14, 1918		Hawkeye Highway	Delaware	15	Gravel	77,001.30	22,297.55	
	5	Oct. 20, 1917	Nov. 5, 1917		do	Buchanan	14.5	do	65,921.98	22,141.35	
	6	Sept. 26, 1917	Oct. 20, 1917		Four sections leading out of Mount Ayr.	Ringgold	12	Graded earth	42,173.89	21,086.95	
	7	Oct. 20, 1917	Dec. 6, 1917		Four radial roads out of Knoxville.	Marion	18	do	61,600.00	22,531.85	
	8	Nov. 1, 1917	Dec. 3, 1917		Jefferson Highway	Decatur	10.4	do	41,625.10	20,812.55	
	9	Nov. 6, 1917	do		3 sections radiating from Iowa City.	Johnson	11.1	1¼ miles brick or concrete, balance earth.	71,775.00	23,859.55	
	10	Jan. 11, 1918			Lake City Road and Pomeroy Road.	Calhoun	18.4	Gravel	80,608.00	22,297.55	
	11	Nov. 28, 1917	Jan. 8, 1918		Jefferson Highway	Warren	15.5	Graded earth	55,671.00	22,297.55	
	12	do	Jan. 14, 1918		Perry-Adel Road	Dallas	16.25	Gravel	57,326.50	23,117.60	
	14	Jan. 11, 1918			Lincoln Highway	Harrison	18.2	Graded earth	69,740.00	27,803.60	
	16	Jan. 21, 1918			Stand Pipe Road	Montgomery	16	do	57,266.00	16,557.20	
Kans	2	Jan. 14, 1918			Thirty-second Street Road, Ozark Trail, and King of Trails.	Labette	44.5	Gravel or macadam.	510,699.39	76,514.91	
	3	do			Santa Fe Trail	Barton	27.5	Brick	852,032.50	127,804.87	
	4	do			Lawrence and Topeka State Road.	Shawnee	10	Concrete	273,100.60	41,010.09	
Ky	1	June 14, 1917	Sept. 28, 1917		Ashland and Cannonsburg.	Boyd	8.13	Brick, concrete, bituminous concrete, etc.	215,268.00	81,300.00	
	2	May 25, 1917	Dec. 1, 1917		Winchester Pike	Fayette	9.96	Bituminous concrete, bituminous macadam, or Kentucky rock asphalt.	111,280.24	55,640.12	
La [4]	1	Mar. 31, 1917	Nov. 5, 1917	Jan. 29, 1918	Alexandria-Marksville Highway.	Rapides Parish.	16.9	Gravel	70,047.60	19,721.76	21,014.28
	6	do	Canceled		Marksville-Ville Platte Highway.	Avoyelles Parish.	7.06	do	39,515.25	[1]	
	7	July 28, 1917	Nov. 5, 1917	Jan. 19, 1918	Fausse River Highway.	Pointe Coupee Parish	22.28	do	95,982.29	40,000.00	40,000.00
	8	do	Oct. 26, 1917	Feb. 1, 1918	Ruston-Arcadia and Ruston Farmerville Roads.	Lincoln Parish.	7.36	2 miles sand-clay gravel, balance graded and drained earth.	27,977.49	[illegible]	13,988.74
	10	do	Jan. 26, 1918		Rayville-Tallulah Road	Richland Parish.	7.77	Gravel	83,486.00	11,743.00	
	12	do	Nov. 3, 1917	Jan. 28, 1918	Baton Rouge-New Orleans Highway.	Ascension Parish.	27.[illegible]	do	153,267.77	26,949.32	37,699.28
	13	Aug. 27, 1917	Sept. 17, 1917		Alexandria-Camp Beauregard Road.	Rapides	4	Warrenite pavement.	93,192.19	44,250.00	45,242.76
	14	Nov. 22, 1917	Dec. 4, 1917		Columbia-Monroe Highway.	Caldwell	10	Sand-clay gravel.	50,286.12	20,000.00	

[1] Withdrawn.

[2] 968-foot bridge.

[3] Or 50 per cent.

[4] No. 2 withdrawn; Nos. 3, 4, and 5 canceled.

[5] 13.76 per cent.

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State.	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length, in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
Maine	1	Mar. 26, 1917	May 4, 1917	Aug. 22, 1917	"Post Road" between Brunswick and Gardiner.	Sagadahoc.	15.57	Bituminous macadam.	$282,666.91	$128,624.43	$141,333.46
	2	Apr. 26, 1917	Canceled.		Pittsfield or main road from Bangor to Waterville.	Somerset	6.98	Gravel	53,156.03	16,730.07	
	3	Oct. 1, 1917	Dec. 1, 1917		Bangor Road, between Augusta and Waterville.	Kennebec	12.88	Bituminous macadam.	246,268.23	123,134.11	
Md.	1	May 28, 1917	June 23, 1917	Aug. 13, 1917	Between Buckeystown and county line.	Frederick	2.01	Concrete	34,308.12	16,550.21	17,154.06
	2	June 1, 1917	do.		Defence Highway on Washington-Annapolis Highway.	Prince George.	3.32	do	71,103.00	33,200.00	
	3	Aug. 13, 1917	Aug. 23, 1917	Oct. 25, 1917	Ellerslie Road	Allegany	2.33	do	52,349.90	23,300.00	23,300.00
	4	Jan. 28, 1918			Oakland-Hutton Road.	Garrett	2.12	do	50,018.32	21,200.00	
	5	Aug. 13, 1917	Aug. 28, 1917	Oct. 25, 1917	Between Monocacy River and Hopeland.	Frederick	2	do	45,883.20	20,000.00	20,000.00
Mass.	1	June 9, 1917	Aug. 4, 1917	Aug. 27, 1917	Acushnet-Fairhaven Road and Long Plain Road.	Bristol	2.182	do	47,483.42	21,820.00	21,820.00
	2	June 14, 1917	(1)	Oct. 31, 1917	"Washington Street" between Norwell and Hanover.	Plymouth	2.708	Bituminous concrete.	38,960.72	19,480.36	19,480.36
	3	June 9, 1917	August 4, 1917	do.	Newburyport Turnpike	Essex and Middlesex.	1.162	Bituminous macadam.	28,223.05	11,620.00	11,620.00
	4	June 14, 1917	(2)	Feb. 13, 1918	"Andover Street" between Middleton and Peabody.	Essex	1.325	do	30,920.45	19,070.00	13,250.00
	5	July 25, 1917	Aug. 31, 1917	Dec. 21, 1917	"North Road"	Berkshire	3.24	Macadam	78,185.25	32,400.00	32,400.00
	6	Sept. 7, 1917	Oct. 29, 1917		Sandwich and Mashpee Road.	Barnstable.	1.818	Bituminous concrete.	20,001.30	10,000.00	
	7	Jan. 18, 1918	Mar. 5, 1918		Main Road between Goshen and Windsor.	Hampshire.	4.61	Macadam	123,890.80	46,100.00	
	8	do.	do.		Athol-Petersham Road.	Worcester	6.896	Bituminous macadam.	163,374.00	68,960.00	
Mich.	1	Aug. 7, 1917			West Michigan Pike	Muskegon and Oceana.	9.922	do	123,080.54	61,540.27	
	2	May 7, 1917	June 26, 1917	Sept. 29, 1917	Saugatuck-Holland Road.	Allegan	5.983	do	77,589.46	39,886.28	38,794.73
	3	June 4, 1917	Sept. 17, 1917		Baraga Road	Baraga	48.262	Graded earth	227,713.86	113,856.93	
	4	July 6, 1917	Sept. 29, 1917		Rogers City-Onaway Road.	Presque Isle	8.62	Gravel	59,536.18	29,768.09	
	6	July 16, 1917	Sept. 18, 1917		Reed City-Cadillac Road.	Osceola	14.08	do	124,000.00	62,000.00	
	7	Nov. 14, 1917	Dec. 5, 1917		Mikado-Oscoda Road	Alcona	5.971	do	50,602.75	25,301.37	
	8	June 28, 1917	July 25, 1917		South Haven-Saugatuck Road	Allegan	7	Bituminous macadam.	98,000.00	49,000.00	
	10	Nov. 21, 1917	Dec. 10, 1917		Dixie Highway, between Standish and Omer.	Arenac	6.683	Gravel	58,322.00	29,161.00	
	12	Jan. 28, 1918			East Tawas-Oscoda Road.	Iosco	9.718	do	66,000.00	33,000.00	
	13	do.			Howell-Fowlerville Road.	Livingston.	6.382	do	91,533.20	40,136.50	
	14	Feb. 8, 1918			Battle Creek-Hastings Road.	Barry	4.399	do	47,512.57	23,756.28	
	15	Nov. 28, 1917	Jan. 17, 1918		Brighton-Howell Road.	Livingston.	4.232	do	32,428.00	16,214.00	
	16	Dec. 15, 1917	do.		Ann Arbor-Jackson Road.	Washtenaw	2	Concrete, asphaltic-concrete, or brick.	51,661.50	20,000.00	
	17	Dec. 20, 1917	do.		St. Ignace-Soo Road	Chippewa and Mackinac.	8	Gravel	77,737.00	38,868.50	
	19	Feb. 2, 1918			Three Rivers-Kalamazoo Road.	St. Joseph	3.97	Stone bottom with gravel top.	42,978.65	21,489.32	
Minn.	1	Dec. 22, 1916	June 9, 1917		Twin Cities-Duluth Road.	Pine	50	Gravel	160,000.00	80,000.00	
	2	Apr. 23, 1917	do.	Sept. 6, 1917	do.	Chisago	31.5	do	110,000.00	55,000.00	55,000.00
	3	Mar. 24, 1917	Aug. 27, 1917		Scenic Highway	Mille Lacs	40	do	100,000.00	50,000.00	
	4	Mar. 1, 1917	Oct. 29, 1917		do.	Crow Wing.	21	do	60,000.00	30,000.00	
	5	do.	June 9, 1917		Capitol National Highway.	Freeborn	16	do	46,200.00	23,100.00	
	6	June 18, 1917	Nov. 16, 1917		Yellowstone Trail	Carver	26.5	Graded and drained earth.	30,000.00	15,000.00	
	7	Mar. 24, 1917	(4)		Minneapolis and Albert Lea Trail.	Hennepin, Carver, and Scott.	3.75		45,000.00	15,000.00	
	8	do.	June 23, 1917		River Road	Winona	6.25	Graded and drained earth.	24,000.00	12,000.00	
	9	Mar. 26, 1917	Aug. 8, 1917		Scenic Highway	Sherburne	8	Gravel	30,000.00	15,000.00	
	11	Aug. 9, 1917	Sept. 29, 1917	Jan. 24, 1918	State Road No. 2	Goodhue	7	do	43,931.15	15,000.00	15,000.00
	12	June 18, 1917	July 19, 1917		St. Paul-Stillwater Road.	Washington	5.3	do	22,506.00	10,000.00	
	13	July 12, 1917	Aug. 14, 1917	Oct. 17, 1917	State Roads Nos. 14 and 15.	Redwood	13.72	Graded and drained earth.	42,739.26	15,742.18	15,742.18
	16	July 19, 1917	Oct. 15, 1917		State Road No. 3	Becker	30.9	Gravel	60,000.00	30,000.00	
	18	July 26, 1917	Sept. 19, 1917		Kellogg-Smithfield Road.	Wabasha	7.5	Graded earth	32,297.00	15,000.00	
Miss.	1	Sept. 11, 1917	Oct. 23, 1917		Tupelo-Fulton-Hamilton.	Itawamba	24	Gravel	90,200.00	45,100.00	
	3	Sept. 3, 1917	Sept. 25, 1917		Raymond-Edwards Road.	Hinds	3	Clay-gravel	13,578.90	5,000.00	
	4	do.	Feb. 27, 1918		Forest Road	Scott	5.5	do	11,165.00	5,000.00	
	6	do.	Dec. 1, 1917		Meridian Road	Newton	14	Earth	23,122.00	11,217.52	
	7	do.	Sept. 28, 1917		Natchez and Mobile Highway.	Greene	22	Graded earth	34,237.00	15,000.00	
	8	do.	Sept. 20, 1917		do.	Perry	21	do	32,972.00	10,000.00	
	9	Oct. 15, 1917	Dec. 12, 1917		Electric Mills-Porterville Road.	Kemper	5.8	Gravel	26,646.00	10,000.00	
	10	do.	Dec. 3, 1917		Brookhaven-Summit Road.	Lincoln	10.7	do	36,784.00	10,000.00	
	11	do.	Nov. 28, 1917		Smithdale-Summit Road.	Amite	7	do	26,223.56	10,000.00	
	12	do.	Dec. 13, 1917		Clarksburg-Morton Road.	Scott	5.3	do	23,848.00	10,000.00	
	13	do.	Dec. 27, 1917		Scott Ferry Road	Madison	4.3	Clay-gravel	19,206.00	8,000.00	

[1] Approved as to portion used for mails, Aug. 9, 1917, and Aug. 24, 1917.

[2] Approved as to post road part, Aug. 17, 1917, and Aug. 27, 1917.

[3] No. 5 withdrawn.

[4] Withdrawn.

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State.	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length, in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
Miss.—Cont.	14	Nov. 2, 1917			Howells Ferry Road	George	13.8	Sand-clay	$20,955.00	$10,000.00	
	15	Dec. 21, 1917	Jan. 17, 1918		Woodville-Centreville Road.	Wilkinson	9	Clay-gravel	31,839.50	15,000.00	
	16	Dec. 21, 1917			Dixie Highway	Simpson	8.4	do	20,313.09	10,000.00	
Mo.	1	July 11, 1917	Nov. 16, 1917		St. Louis and Kansas City.	Cole	25.8	Gravel	114,297.92	28,574.48	
	2	July 21, 1917	Sept. 19, 1917	Feb. 18, 1918	Galena-Joplin-Webb City Road.	Jasper	7.5	Concrete	119,211.40	24,376.75	$29,802.85
	3	Aug. 18, 1917	Oct. 15, 1917		Nevada-Milo Road	Vernon	6.5	Macadam	38,420.42	9,605.10	
	4	Feb. 15, 1918			National Old Trails Road.	Boone	3	Bituminous macadam.	21,458.36	10,729.18	
Nebr.	1	Oct. 6, 1917	Oct. 20, 1917		O. L. D. Highway	Lancaster	5.5	Brick	204,683.05	17,847.50	
	2	Oct. 18, 1917	Dec. 10, 1917		Washington Highway and King of Trails.	Richardson, Nemaha, and Otoe.	57.25	1 mile gravel, balance earth.	69,198.80	34,599.40	
	3	Jan. 8, 1918			Lincoln Highway	Hall	32.1	Earth	39,531.58	19,765.79	
	4	Nov. 1, 1917			Omaha-Yankton Highway.	Wayne and Cedar.	61.25	Sand-clay	59,525.51	25,698.75	
	5	Feb. 2, 1918			Columbus-Norfolk Road.	Madison and Platte.	52.25	Earth and sand-clay.	53,166.52	26,583.26	
	6	Nov. 5, 1917			Kearney-Broken Bow Highway.	Buffalo, Sherman, and Custer.	76	Earth	92,399.91	46,199.95	
	7	Feb. 2, 1918			Minden-Superior Highway.	Kearney, Adams, Clay, and Nuckolls.	94	Sand-clay	86,773.52	43,386.76	
Nev.	1	Oct. 22, 1917	Dec. 12, 1917		Part of Overland Trail	Humboldt	17.5	Gravel	92,189.94	46,094.97	
	2	do	Dec. 6, 1917		Part of Midland Trail, also section Route No. 4.	Nye	14.3	do	35,790.66	17,895.33	
	3	Nov. 12, 1917	Dec. 15, 1917		Fallon-Hazen Road	Churchill	8	Sand-clay	57,195.20	28,597.60	
	4	do	Dec. 5, 1917		Gardnerville-Holbrook Road.	Douglas	4	25 per cent macadam, balance graded earth.	11,230.12	5,615.06	
	5	Dec. 22, 1917	Jan. 17, 1918		Carlin-Elko Road	Elko	20	Gravel	97,812.00	48,906.00	
	6	Jan. 10, 1918	Feb. 27, 1918		Ely-Hamilton Road	White Pine	12	Gravel or macadam.	62,469.33	31,234.66	
N.H.	1	Dec. 21, 1916	May 4, 1917	Aug. 16, 1917	"Lafayette Road"	Rockingham.	1.15	Bituminous gravel.	16,341.14	7,494.85	8,170.57
	2	June 4, 1917	Aug. 31, 1917	Dec. 11, 1917	South Side Road	Cheshire	1.26	Gravel and macadam.	14,051.13	7,000.78	7,025.56
	3	Dec. 29, 1916	(1)								
	4	June 4, 1917	Aug. 23, 1917	Dec. 18, 1917	"Winnipesaukee" or "Lake Shore Road."	Belknap	2.25	Gravel	15,725.16	7,500.00	7,862.58
	5	do	do	Dec. 6, 1917	Dover and Rochester Road.	Rockingham and Strafford.	2.26	do	14,952.85	7,500.00	7,476.42
	6	do	do	Oct. 31, 1917	"Newport Road"	Merrimack	1.51	do	11,863.23	4,750.00	5,931.61
	7	do	do	Nov. 3, 1917	Mascoma Valley Road	Merrimack and Grafton.	2.42	do	20,343.23	7,500.00	10,171.61
	8	do	do		Part of road from Claremont to Plymouth.	Sullivan	.74	Telford with modified asphalt surface.	11,797.00	5,898.50	
	9	do	do		East Side Road	Coos	.85	Bituminous gravel.	12,991.68	6,495.84	
	10	Jan. 30, 1918			Sunapee Lake Road	Grafton and Merrimack.	1.55	Gravel	16,007.31	8,003.65	
	11	Feb. 4, 1918			do	Merrimack	1.52	do	9,937.84	4,968.92	
	12	Feb. 16, 1918			Rockingham Road	Rockingham.	1.75	do	11,989.89	5,994.94	
N. J.	1	May 28, 1917	Nov. 5, 1917		Malaga-Penn's Grove Road.	Salem	9.25	Concrete, bituminous macadam, and gravel.	164,988.01	59,212.68	
N. Mex.	1	Sept. 18, 1917	Dec. 27, 1917		Old Santa Fe Trail	Colfax	71.6	Gravel	157,900.00	78,950.00	
	2	do	do		Part of State Road No. 21.	Mora	12.9	Crushed rock or gravel.	68,200.00	34,100.00	
	3	Oct. 11, 1917	do		National Old Trails Route.	Santa Fe	9	Gravel	26,965.00	13,480.00	
	4	Oct. 19, 1917	do		National Old Trails Road.	Valencia	34.7	Graded earth, surfaced where needed.	37,570.50	18,785.25	
	5	Nov. 14, 1917	Dec. 11, 1917		Tucumcari-Montoya	Quay	22	Plain macadam	84,782.24	42,391.12	
	6	do			Tucumcari-Glenrio Highway.	do	1	Gravel	4,179.66	2,089.83	
	7	Oct. 30, 1917	Nov. 17, 1917		Revuelto Road	do	3	Graded earth, surfaced with gravel where needed.	10,575.99	5,287.99	
	8	Nov. 14, 1917	Dec. 1, 1917		Mescalero Sand Road	Chaves	7	Macadam	27,999.86	13,999.93	
	9	Nov. 17, 1917	Dec. 3, 1917		Silver City-Gila River Road.	Grant	17	Gravel	55,484.00	27,742.00	
	10	Nov. 16, 1917	do		Borden Hill-Honda Road.	Lincoln	25	do	116,479.00	58,239.50	
	11	Nov. 17, 1917	do		Roswell-Carrizozo Road	do	5	do	25,371.50	12,685.75	
	12	Nov. 26, 1917	Dec. 12, 1917		Roswell-Tatum Road	Chaves	15.5	Gravel or macadam.	112,178.00	56,089.00	
N. Y.	1	Sept. 13, 1917	Sept. 25, 1917		Brockton-Fredonia Road.	Chautauqua	4.64	Concrete	92,800.00	46,400.00	
	2	do	do		Perry Center-Moscow Road.	Wyoming	2.59	Bituminous macadam.	51,195.10	25,597.55	
	3	do	do		Greene-Oxford Road	Chenango	11.44	do	227,693.00	113,846.50	
	4	do	do		Fredonia-Silver Creek Road.	Chautauqua	4.2	Concrete	83,999.00	41,999.50	
	5	Oct. 29, 1917			Copake-Mount Riga Road.	Columbia	7.33	Concrete or macadam.	135,875.00	67,937.50	
	6	Sept. 13, 1917			New York State Line-Nyack Road.	Rockland	5.57	Macadam or concrete.	110,000.00	55,000.00	
	7	Jan. 18, 1918			Nicholville-St. Regis Falls Road.	St. Lawrence	3.5	Bituminous macadam.	55,000.00	27,500.00	
	8	Feb. 18, 1918			Alton-Wolcott Road	Wayne	3.21	Bituminous macadam or concrete.	63,900.00	31,950.00	

[1] Superseded by project No. 9.

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State.	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designations of road.	County.	Length, in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
N. C.	1	Dec. 20, 1916	Apr. 21, 1917	June 23, 1917	Bridge across Catawba River.	Mecklenburg and Gaston.	(1)	Bridge	$51,956.52	$10,000.00	$10,000.00
	2	Mar. 23, 1917	Apr. 26, 1917	Aug. 16, 1917	Hickery Nut Gap Road.	Henderson.	7.75	Graded earth	26,392.83	10,000.00	13,196.41
	3	do	June 29, 1917	Nov. 23, 1917	Swannonoa Gap Road.	McDowell.	2.85	do	26,490.50	10,000.00	10,000.00
	4	Oct. 3, 1917	Oct. 20, 1917	....	Beaufort Road	Craven	9.5	Topsoil and sand-clay.	20,000.00	10,000.00	....
	5	June 11, 1917	Aug. 7, 1917	Jan. 17, 1918	Central Highway	Burke	8.03	Topsoil	20,985.27	5,000.00	5,000.00
	7	do	(2)	....	Wilmington - Fayetteville Highway.	Sampson	47.5	Sand-clay and gravel.	66,929.28	10,000.00	....
	8	do	Oct. 17, 1917	....	do	Cumberland	13.8	Sand-clay gravel.	28,956.87	5,000.00	....
	10	Oct. 4, 1917	Oct. 20, 1917	....	Denton-Troy Road	Davidson	7.5	Topsoil or gravel.	19,595.13	8,000.00	....
	11	Oct. 22, 1917	Nov. 5, 1917	....	Central Highway	Lenoir	1.75	Concrete	32,967.00	10,000.00	....
	12	June 11, 1917	Aug. 31, 1917	Feb. 9, 1918	do	Wayne	8.23	Sand-clay-gravel.	17,769.40	5,000.00	5,000.00
	14	June 28, 1917	Sept. 13, 1917	....	New Hope Road	Halifax	8	Clay-gravel	13,809.19	5,000.00	....
	15	Aug. 13, 1917	Aug. 3, 1917	Feb. 9, 1918	National Highway to Danville, Va.	Guilford	14.55	Topsoil and bituminous macadam.	26,834.41	7,500.00	7,500.00
	16	Aug. 24, 1917	Sept. 18, 1917	....	Asheville - Atlanta - Knoxville Highway.	Haywood	14.27	Gravel and sand-clay.	27,132.16	8,000.00	....
	17	Jan. 7, 1918	Jan. 21, 1918	....	North Wilkesboro-Deep Gap-Boone Highway.	Wilkes	25	Graded earth	53,790.00	25,000.00	....
	18	Oct. 25, 1917	Dec. 7, 1917	....	Taylorsville - Wilkesboro Road.	Alexander	11	Topsoil	27,332.36	10,000.00	....
	19	Jan. 23, 1918	....	....	National Highway	Rockingham.	8.22	do	24,218.96	10,000.00	....
	20	Jan. 28, 1918	....	....	Yadkinville - Wilkesboro Road.	Yadkin	7	do	16,543.44	5,000.00	....
	21	Feb. 6, 1918	....	....	Roxboro-Virginia Road	Person	7.55	Sand-clay or topsoil.	17,934.29	5,000.00	....
N. Dak.	1	July 12, 1917	Aug. 30, 1917	....	Meridian Road	Cass	17	Graded earth	15,444.00	7,722.00	....
	2	do	do	....	5 miles on Primary Road and 10 miles on Secondary Road.	Foster	15	1½ miles gravel, balance earth.	11,781.00	5,890.50	....
	3	Jan. 5, 1918	....	....	Wonderland Trail	Williams	30.5	Earth	39,658.04	19,829.02	....
	4	Aug. 10, 1917	....	....	Meridian Road	Richland	20	do	13,407.43	6,703.71	....
	6	Jan. 21, 1918	....	....	Black Trail	Eddy	5.5	Gravel and earth.	6,653.53	3,326.76	....
	7	Feb. 4, 1918	....	....	New Home Road	Stutsman	9.2	Earth	12,972.96	6,486.48	....
	8	Jan. 21, 1918	....	....	Fessenden-New Rockford-Carrington Road.	Eddy	9.5	Gravel	23,949.24	11,974.62	....
	9	Feb. 5, 1918	....	....	Meridian Road	Grand Forks.	3.6	do	11,456.50	5,728.25	....
	10	Feb. 6, 1918	....	....	Balta Road	Pierce	5	1 mile gravel, 4 miles sand-clay.	7,999.64	3,999.82	....
	11	Feb. 11, 1918			Rock Lake - Langdon Road.	Cavalier	7.8	Graded earth	7,190.92	3,595.46	....
	12	Feb. 7, 1918	....	....	Black Trail and Red Trail.	Barnes	29.6	Earth and gravel.	47,775.09	23,887.54	....
	13	Feb. 9, 1918			Pingree - Woodworth Road.	Stutsman	7.9	Earth	15,080.19	7,540.09	....
	14	Feb. 11, 1918	....	....	Black Hills Auto Trail.	Stark	18.9	do	18,944.26	9,472.13	....
	16	Feb. 8, 1918	....	....	Wonderful Trail	Grand Forks.	6.9	Gravel	17,295.12	8,647.56	....
	17	Feb. 11, 1918	....	....	Red and Yellow Trail.	Griggs	17.5	Earth	21,707.40	10,853.70	....
	18	Feb. 13, 1918	....	....	Wonderful Trail	Ramsey	5.3	do	3,729.17	1,864.58	....
Ohio	1	May 4, 1917	Oct. 17, 1917	Dec. 1, 1917	Old National Road	Muskingum	13.63	Brick or concrete.	488,501.00	136,300.00	136,300.00
	2	May 17, 1917	Sept. 6, 1917	Oct. 17, 1917	River Road	Lucas	4.48	Macadam and concrete.	76,900.00	37,000.00	37,000.00
	3	May 18, 1917	do	Oct. 16, 1917	do	do	3.73	Concrete	90,300.00	37,300.00	37,293.00
	4	Aug. 20, 1917	Sept. 28, 1917	Dec. 1, 1917	Cleveland - Buffalo Highway.	Lake	7.715	Reinforced concrete or semi-monolithic brick.	270,209.28	77,150.00	77,150.00
	5	do	do	Dec. 3, 1917	do	do	5.433	Reinforced concrete or monolithic brick.	189,170.00	54,330.00	54,330.00
	6	Aug. 31, 1917	Nov. 2, 1917	Dec. 1, 1917	Ashland-Wooster Road.	Ashland	2.47	Monolithic brick.	68,000.00	24,600.00	24,600.00
	7	do	Sept. 20, 1917	Dec. 3, 1917	Columbus-Wooster Road.	do	1.542	do	46,500.00	15,400.00	15,400.00
	8	Jan. 18, 1918	....	....	do	Knox	4	Brick or concrete.	163,893.40	40,000.00	....
	9	do	....	....	do	do	2	do	65,289.13	10,000.00	....
	10	Jan. 21, 1918	....	....	Cleveland - Wooster Road.	Wayne	5	Bituminous macadam or brick.	140,662.50	50,000.00	....
	11	Feb. 19, 1918	....	....	Cleveland - Buffalo Road.	Ashtabula	11.92	Brick or concrete.	431,790.00	119,000.00	....
	12	Feb. 15, 1918	....	....	Ashland-Wooster Road.	Wayne	6.71	Brick	170,541.95	50,000.00	....
Okla.	2	Oct. 10, 1917	Nov. 16, 1917	....	Broken Bow-Smithville Road.	McCurtain.	25	Gravel	100,058.75	50,029.37	....
Oregon.	1	Aug. 15, 1917	(3)	....	Pacific Highway	Josephine	4.9	Graded earth	83,606.50	41,800.00	....
	2	Sept. 11, 1917	(4)	....	do	Douglas	10.8	Macadam	233,653.75	108,000.00	....
	3	do	(5)	....	do	do	4.8	Graded and drained earth.	38,065.50	19,032.75	....
	4	Oct. 20, 1917	Dec. 4, 1917	....	John Day Highway	Wheeler	9.47	Earth	36,733.40	18,366.70	....
	5	Dec. 10, 1917	Feb. 25, 1918	....	Elgin-Minam Road	Union	9.3	do	36,094.30	18,047.15	....
	6	Dec. 20, 1917	....	....	John Day Highway	Grant and Wheeler.	48.45	do	400,433.79	157,216.89	....
	7	Dec. 28, 1917	....	....	Pacific Highway	Marion	21	Bituminous macadam.	359,546.00	179,773.00	....
Pa.	1	Oct. 5, 1916	Feb. 17, 1917	May 11, 1917	Waterford and Susquehanna Turnpike.	Clarion	2.675	Vitrified brick on concrete foundation.	70,857.65	26,750.00	26,750.00
	2	do	Mar. 21, 1917	do	Washington Pike	Washington	6.48	Reinforced concrete.	160,433.53	64,800.00	64,800.00
	3	do	Feb. 13, 1917	do	Johnstown and Mundys Corner Road.	Cambria	6.234	Brick on concrete base.	138,466.49	62,340.00	62,340.00

[1] 1,760 feet.

[2] Not included in 1918 schedules.

[3] Disapproved Sept. 29, 1917.

[4] Disapproved Oct. 17, 1917.

[5] Canceled after being approved for 2.4 miles used for mails.

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State.	Project No	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length, in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
Pa. (con.)	4	Oct. 3, 1917	Oct. 20, 1917	Nov. 23, 1917	Kane-Mount Jewett Road.	McKean	4.186	Vitrified brick.	$158,674.78	$41,860.00	$41,860.00
	5	Nov. 1, 1917	Dec. 1, 1917		Johnstown Road	Somerset	7.45	Reinforced concrete or bituminous concrete and vitrified brick.	308,290.62	74,500.00	
	6	do	do		Altoona-Tyrone Road	Blair	3.01	Bituminous concrete.	91,319.08	30,100.00	
	7	Nov. 22, 1917	Dec. 3, 1917		Wampum-New Castle Road.	Lawrence	4.98	Reinforced concrete.	180,746.50	49,800.00	
	8	Jan. 7, 1918	Jan. 29, 1918		Buffalo Ridge Road	Erie	28.3	Cement concrete or bituminous concrete on concrete base.	809,380.00	283,000.00	
	9	Feb. 2, 1918	Feb. 28, 1918		State Highway Route No. 13.	Butler	3.69	Reinforced concrete.	129,888.00	36,900.00	
	10	do	do		State Highway Route No. 77.	Lawrence	2.33	do	84,579.00	23,300.00	
	11	do	do		State Highway Route No. 18.	Lycoming	6.97	do	230,010.00	69,700.00	
	13	do	do		State Highway Route No. 71.	Armstrong	4.1	do	157,850.00	41,000.00	
	16	do			State Highway Route No. 73.	Butler	3.3	do	127,050.00	33,000.00	
R. I.	1	Apr. 24, 1917	May 29, 1917	Sept. 13, 1917	Post Road	Washington	3.64	Bituminous concrete.	85,444.16	34,997.13	34,997.13
S. C.	1	Aug. 28, 1917	Sept. 15, 1917		Garners Ferry Road	Richland	2.12	Concrete	49,846.94	23,248.20	
	2	do	do		National Highway	Spartanburg	14.9	Concrete or brick and topsoil.	132,706.68	48,577.87	
	3	Aug. 29, 1917	do		do	Greenville	4.9	Concrete	76,899.90	38,449.95	
	4	Oct. 11, 1917	Nov. 8, 1917	Dec. 22, 1917	Cherry Road	York	3	Cement concrete.	36,757.69	18,378.84	18,378.84
	5	do	do		Washington-Atlanta Highway.	Chesterfield	2.14	Gravel	11,911.02	5,955.51	
Tenn.	1	Nov. 12, 1917	Jan. 17, 1918		Chattanooga-Birmingham Pike.	Hamilton	1.87	Macadam	42,598.66	21,299.33	
	2	do	Feb. 27, 1918		Chattanooga-Whitwell Pike.	do	3.6	do	36,855.81	18,427.90	
Tex.	1	Oct. 13, 1917	Dec. 5, 1917		Dougherty Highway	Culberson	50.4	Grading and gravel where required.	45,265.55	22,632.77	
	2	do	Dec. 4, 1917		Edinburg Road	Brooks	20	Sand-clay or gravel.	42,077.75	21,038.87	
	3	do	Dec. 1, 1917		Section of Meridian Road.	Wichita	8.9	Bituminous gravel.	87,737.10	43,868.55	
	4	do	do		Austin-Pflugerville Road.	Travis	6	do	25,389.10	12,500.00	
	5	do	Dec. 3, 1917		Monahan-Grand Falls Road.	Ward	17.5	Gravel	26,141.50	13,070.75	
	6	Nov. 5, 1917	Dec. 7, 1917		Fort Worth-El Paso Highway.	Shackleford	9	do	30,221.68	15,110.84	
	7	Nov. 26, 1917	Dec. 19, 1917		do	Mitchell	7.5	do	25,867.60	12,933.80	
	8	do	Dec. 20, 1917		Austin-San Antonio Post Road.	Hays	24.8	Gravel, bituminous topping.	43,131.00	21,565.50	
	10	Jan. 10, 1918			Meridian Highway	Williamson	21.5	Gravel base, bituminous top.	106,375.50	50,000.00	
	11	Nov. 5, 1917			Seven Mile Road	McLennan	1.25	Gravel with asphalt surface.	10,003.07	5,000.00	
	12	do			Waco-Marlin Road	do	3.5	Bituminous gravel.	25,003.00	12,500.00	
	13	do			Waco-Valley Mills	do	3	do	25,088.80	12,500.00	
	14	Jan. 1, 1918			Meridian Road	Wise	42.3	Gravel, possibly bituminous top.	170,000.00	80,000.00	
	15	Dec. 11, 1917	Jan. 8, 1918		Part of Central Route or State Highway No. 3.	Wharton	3.3	Bituminous gravel.	23,526.70	11,763.35	
	16	do	Jan. 17, 1918		Puget Sound-Gulf Highway.	McColloch	37.4	Gravel and sand-clay.	75,774.60	35,000.00	
	17	Dec. 26, 1917			Puget Sound-Gulf Highway.	Mason	24	Sand-clay and gravel.	22,533.50	11,266.75	
	18	Jan. 23, 1918			Winfield-Saltillo Highway.	Franklin	12.15	Gravel	49,500.00	24,750.00	
	19	Dec. 26, 1917			Fort Worth-El Paso	Eastland	28.3	do	117,983.80	35,000.00	
	20	Nov. 28, 1917	Dec. 20, 1917		Meridian Highway	Johnson	33.89	do	89,365.10	44,682.55	
	21	Dec. 26, 1917			Jefferson Highway	Gregg	14.6	Bituminous macadam.	57,995.72	19,000.00	
	22	Dec. 22, 1917			Maple Avenue between Dallas city limits and Love Aviation field.	Dallas	3	Macadam with asphalt surface.	20,401.48	10,200.00	
	23	do			Rowlett-Dallas-Rockwall Road.	do	3.00	Gravel	14,000.00	7,000.00	
	24	do			Dallas-Fort Worth Road.	do	1	Concrete	20,000.20	10,000.00	
	25	do			Millers Ferry Road	do	3	Macadam with asphalt surface.	19,999.98	10,000.00	
	26	Jan. 10, 1918			El Paso-Texarkana Road.	Titus	8	Bituminous gravel.	56,039.69	28,019.84	
	27	Jan. 5, 1918			Jefferson Highway	do	11.25	do	19,800.00	9,900.00	
	28	Feb. 2, 1918			Omaha-Cookville and Omaha-Naples.	Morris	10.88	Sand-clay	65,200.00	32,600.00	
	29	Jan. 5, 1918			Del Rio-Canadian	Val Verde	3.64	Gravel	25,687.90	12,843.95	
	30	Jan. 14, 1918			East Texas Highway	Jasper	13.6	do	71,696.90	30,000.00	
	32	Feb. 13, 1918			Washington Avenue and Webster Air Line.	Harris	3.183	Concrete with bituminous top.	113,221.22	34,602.19	
	34	Jan. 12, 1918			Fort Worth-Roswell Highway.	Dickens	6.5	Gravel	32,439.00	15,345.00	
	35	Jan. 14, 1918			Seguin-Gonzales Road.	Guadalupe.	15.7	Gravel with bituminous top.	69,789.50	34,894.75	
	36	Jan. 24, 1918			Middle Buster Highway.	Caldwell	15.8	Gravel	77,061.82	35,000.00	

RECORD OF FEDERAL AID, TO MARCH 1, 1918—Continued.

State	Project No.	Date submitted.	Date approved.	Plans, specifications, and estimates approved.	Local designation of road.	County.	Length in miles.	Type of construction.	Total estimated cost.	Federal aid requested.	Federal aid allowed.
Tex. (con.)	37	Jan. 19, 1918			Central Route Highway.	Fayette	11	Bituminous gravel.	$73,546.00	$36,773.00	
	41	Jan. 22, 1918			Saginaw Road	Tarrant	10	do	68,740.65	34,370.32	
	42	do			Weatherford Road	do	6.2	do	28,619.25	14,309.63	
Utah	1	July 3, 1917	Sept. 27, 1917		Castle Gate-Duchesne Road.	Carbon and Duchesne	45	Earth	77,400.00	38,700.00	
	2	Aug. 14, 1917			Ogden-Hooper Road	Weber	9.6	Macadam	32,818.75	16,409.37	
	4	Sept. 15, 1917			Price-Emery Road	Emery and Carbon.	63	Graded earth	109,923.00	54,961.50	
	5	Nov. 23, 1917	Jan. 17, 1918		Thompsons-Moab Road	Grand	35	do	50,685.25	25,342.62	
	6	do	do		Moab-La Sal Junction Road.	Grand and San Juan.	24	do	34,755.60	17,377.80	
	7	do	do		La Sal Junction-Monticello Road.	San Juan	36	do	52,133.40	26,066.70	
	8	do	do		Monticello-Blanding Road.	do	25	do	36,203.75	18,101.87	
Vt.	1	June 14, 1917	July 25, 1917		French Hill Road	Chittenden.	.9	Gravel	9,991.52	4,995.76	
	2	do	do	Dec. 11, 1917	Winooski River Road	Washington	.793	Gravel with stone base.	10,192.46	3,225.47	$5,096.23
	3	July 5, 1917	Aug. 31, 1917		St. Johnsbury - Wells River Road.	Caledonia	.7	Gravel on stone base.	11,935.79	5,967.89	
	4	do	Sept. 5, 1917		Old Stage Road	Addison	1.4	Gravel	10,135.75	5,067.87	
	5	July 7, 1917	Aug. 31, 1917		Richford Road	Franklin	.75	do	7,380.12	3,690.06	
	6	Aug. 14, 1917	do		River Road	Orange	2.4	Gravel or macadam.	11,792.44	5,896.22	
	7	do	do		Brattleboro - Wilmington Road.	Windham	1.65	Gravel	13,308.34	6,654.12	
	8	Aug. 22, 1917	Sept. 4, 1917		Gulf Road	Caledonia	1.25	do	7,928.80	3,964.40	
	9	do	Sept. 19, 1917		Morrill Hill Road	Orleans	2.85	do	25,961.58	12,980.79	
Virginia	1	May 11, 1917	June 4, 1917	Aug. 27, 1917	Moccasin Gap Road	Russell	4.38	Gravel and macadam.	28,441.22	14,236.75	14,220.61
	2	May 21, 1917	July 12, 1917	Sept. 18, 1917	Marumsco-Neabsco Road.	Prince William.	3.51	Gravel	37,814.72	10,000.00	12,857.06
	3	June 11, 1917	July 20, 1917		Kecoughton Road	Elizabeth City.	3.45	Concrete	50,000.00	22,500.00	
	4	July 7, 1917	Aug. 2, 1917	Sept. 20, 1917	Danville-Martinsville Highway.	Pittsylvania.	8.03	Topsoil	16,797.44	10,650.00	8,398.72
	5	Dec. 4, 1917	Dec. 2, 1917		Harrisonburg-Warm Springs Turnpike.	Augusta	5.682	Macadam	45,250.17	22,625.08	
	6	Dec. 28, 1917	Jan. 8, 1918		Moccasin Gap Road	Russell	3.58	do	33,103.30	16,551.65	
Wash.	1	Mar. 24, 1917	Apr. 25, 1917	July 19, 1917	Pacific Highway	Thurston	3.52	Concrete	61,730.45	30,865.22	30,865.22
	2	May 24, 1917	July 16, 1917	Nov. 8, 1917	Navy Yard Highway	Mason and Kitsap.	9.9	Gravel	85,405.99	41,018.94	41,018.95
	3	June 12, 1917	July 26, 1917	Feb. 13, 1918	State Road No. 22	Stevens	5.92	do	33,142.18	20,000.00	16,571.09
	4	May 29, 1917	do	Jan. 28, 1918	Pacific Highway	Clarke	3.62	Gravel or macadam.	78,065.57	35,000.00	35,000.00
	5	June 23, 1917	Sept. 27, 1917	Dec. 28, 1917	do	Cowlitz	5.22	Graded and drained earth.	91,194.51	40,000.00	40,000.00
	6	May 25, 1917	Aug. 8, 1917	Dec. 7, 1917	Kamilche section of Olympic Highway.	Mason	3.41	Gravel	47,724.19	20,000.00	20,000.00
	7	July 20, 1917	Nov. 17, 1917		Sunset Highway	Lincoln	8.3	Gravel or macadam.	60,714.50	28,768.56	
W. Va.	1	July 21, 1917	Aug. 16, 1917	Jan. 28, 1918	Ronceverte and Lewisburg Highway.	Greenbrier.	2.53	Asphaltic concrete.	32,857.08	9,246.48	9,246.48
	2	Feb. 14, 1918			Fetterman-Pruntytown Road.	Taylor	2	Brick surface on concrete base.	57,420.00	8,000.00	
	3	Dec. 22, 1917	Jan. 17, 1918		Petersburg-Franklin Road.	Pendleton	10	Graded and drained earth.	36,000.00	12,500.00	
	4	Feb. 14, 1918			Brandonville and Fishing Creek Turnpike.	Marion	2.4	Brick road on concrete base.	43,461.00	13,000.00	
	5	Jan. 11, 1918			Westover-Randall Road.	Monongalia	2.6	Cement concrete.	60,247.00	18,000.00	
	7	Feb. 14, 1918			Round Bottom	Wetzel	1.3	Concrete	30,319.30	8,645.00	
	8	Feb. 25, 1918			Wilson Creek-Elmwood Road.	Wayne	2	do	60,930.00	8,930.00	
	10	do			Clarksburg Road	Mason	5.89	do	133,000.00	16,530.00	
	12	do			Seneca Pike	Randolph	1.89	Earth	9,197.10	4,598.55	
Wis.	1	July 5, 1917	Dec. 20, 1917		Sheridan Road, also known as Lake Shore Highway.	Racine	3.2	One-course cement-concrete.	53,900.00	17,966.66	
	2	do			Lake Shore Road	Manitowoc.	.61	Bridge, 21-foot span.	22,161.92	7,387.30	
	3	do			Sheridan Road	Kenosha	1.5	Cement concrete.	28,429.50	9,476.50	
	4	Feb. 2, 1918			Shawano-Green Bay Road.	Shawano	7.33	Gravel	36,102.00	12,034.00	
	7	Feb. 19, 1918			Watertown Plank Road	Waukesha.	3.66	Water-bound macadam.	29,975.00	9,991.66	
	8	Feb. 1, 1918			Madison - Middleton Road.	Dane	3.4	Concrete	75,622.27	25,207.42	
	9	do			Green-Bay-Kewaunee	Kewaunee.	(2)	Gravel macadam.	9,152.00	3,050.66	
	12	Sept. 25, 1917			Madison - Sauk City Road.	Dane	2.73	Water-bound macadam.	29,645.00	9,881.66	
	19	Feb. 2, 1918			Prentice-Phillips Road.	Price	6.9	Earth	20,790.00	6,930.00	
Wyo.	1	June 12, 1917			Casper-Salt Creek Road	Natrona	45		59,670.00	29,835.00	
	2	June 16, 1917	Oct. 17, 1917		Medicine Bow-Marshall Road.	Albany	23.4	Earth	10,349.94	5,174.97	
	3	June 19, 1917			Cokeville-Star Valley Road.	Lincoln	30		15,862.00	7,931.00	
	4	June 25, 1917	Jan. 10, 1918		Hat Creek-Warren Road.	Niobrara	6.76	Graded and drained earth.	9,999.95	4,999.97	
	5	July 3, 1917	Dec. 12, 1917		Eden Valley Road.	Sweetwater	14	Earth	15,987.40	7,993.70	
	7	July 5, 1917	Jan. 10, 1918		Carter-Lyman Road	Uinta	1.5	Graded and drained earth.	2,242.02	1,121.01	
	8	July 17, 1917			Cody-Meeteetse Road	Park		4 bridges	8,564.52	4,282.26	
	10	July 24, 1917	Nov. 16, 1917		Part of Wheatland-Laramie Road, including 2 bridges.	Platte	1.2	Earth	4,100.23	2,050.11	
	12	Aug. 8, 1917	do		Part of Big Piney Road.	Lincoln	4.12	Gravel	8,125.15	4,062.57	
	17	Nov. 16, 1917	Jan. 10, 1918		Fort Bridger-Urie Road	Uinta	3.83	Graded and drained earth.	5,896.00	2,948.00	

[1] Withdrawn.

[2] 7,900 feet.

FEDERAL AID PROJECTS IN IDAHO.

The projects upon which the Idaho State Highway Commission expects to use Federal aid funds in 1918 are:

(*a*) Portions of the north and south highway lying between New Meadows and Grangeville, in Idaho County;

(*b*) A portion of Lost River Highway, in Custer County; and

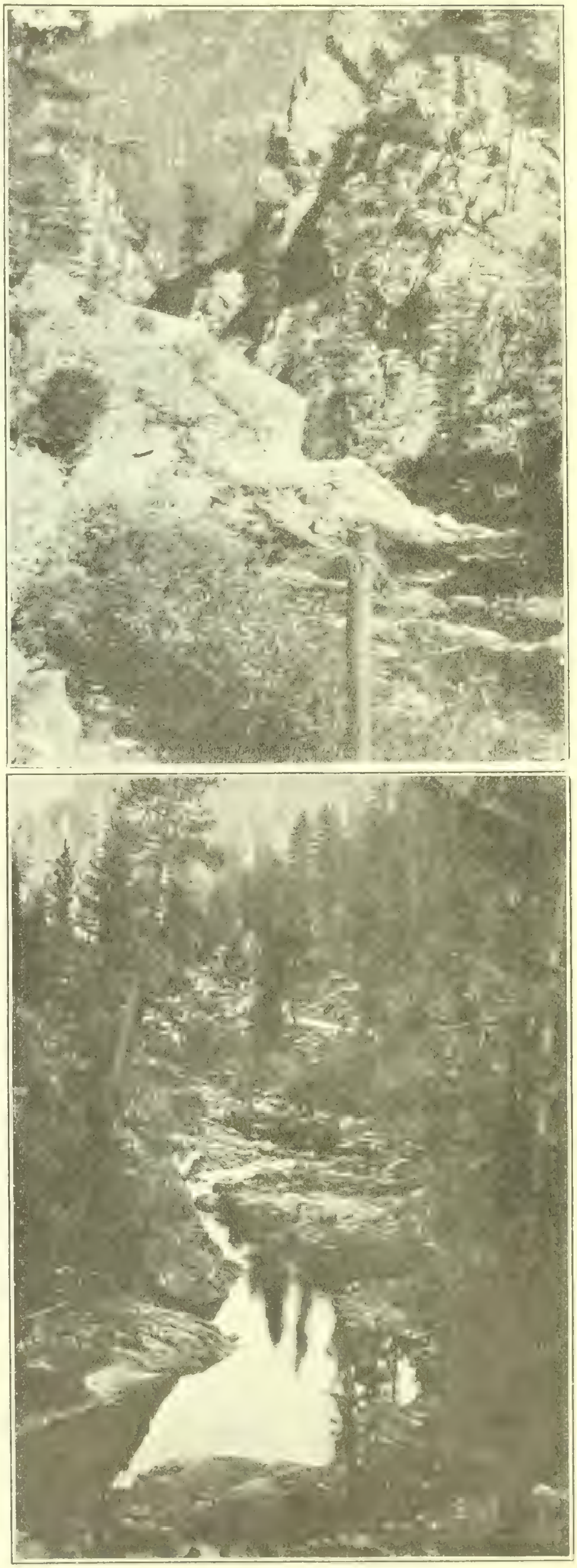
(*c*) A portion of Sawtooth Park Highway, in Lemhi County.

It can be argued that all of these are meritorious post-road projects and are urgently needed. The roads of which these are a part have a total mileage of about 208, and the building of approximately one-half is contemplated this year.

The people of the entire State, and particularly the adjoining communities, are much interested in the first-named road. Because of the topography of the country, the Salmon River Canyon, through which it will run, is the only possible route lying within the State which connects the north and south portions. At present only a dangerous stage trail traverses the canyon, which in reality is little short of an effective barrier separating the two sections of the State. It is expected to let contracts from Grangeville southward and build during the season to and south from Whitebird a few miles—about 23 miles in this vicinity. Also, beginning 10 miles below New Meadows, it is intended to build northward through about 5 miles of extremely rough canyon, making a total of approximately 28 miles of the 88 miles of post road on north and south highway to be built this year, at a total cooperative cost of approximately $320,000.

(*b*) The Mackay-Challis section is 60 miles long and the estimated cost $190,000, this being the easiest construction encountered. This link is urgently needed because of the isolated mining region and other infant industries it will serve and from which high-grade ores are now being brought out 60 to 100 miles on motor trucks and wagons to the rail terminus at Mackay. The present rate of trucking supplies in from Mackay to Challis, the county seat, is $20 per ton. Rapid development undoubtedly will follow road construction.

(*c*) The section of highway from Salmon to Challis is quite rough, narrow, and has many dangerous turns in the present road; the project contemplated this year will build from Salmon southward some 30 miles. Cooperative State, county, and Federal funds will be used to the extent of about $200,000, and it is believed that the greater portion of the dangerous places will be covered, thereby eliminating the danger of accidents to tourists and strangers who traverse this wonderfully scenic region, as well as make safer traffic conditions for residents. It is expected also to secure daily mail service between Salmon and Challis, instead of alternate daily service now maintained.



Along the Little Salmon.

IOWA'S FIRST PROJECT NEARLY COMPLETE.

IOWA'S first Federal aid project, 4.07 miles in length, is a link in the road connecting Mason City and the city of Clear Lake, in Cerro Gordo County. Mason City is an important manufacturing center, having very large Portland cement and clay products industries. Clear Lake is a popular summer resort. Many residents of Mason City have their summer homes at Clear Lake and during this season travel back and forth in automobiles. Two miles of the road between the two cities had been paved with concrete, 16 feet wide, previous to the promotion of this project, which will provide, when completed, a pavement from the west corporate limit of Mason City to the east corporate limit of Clear Lake.

The pavement is built of reinforced concrete to a width of 16 feet, and has a thickness of 7½ inches at the center and 6 inches at the sides, with no expansion joints. Before placing the concrete the roadbed was graded level from side to side, the additional 1½ inches in the depth of the concrete at the center providing the crown of the pavement. The concrete was proportioned: One part Portland cement, two parts sand, and three parts broken stone. The sand used in the work was obtained from local pits and washed and screened. The coarse aggregate was Wisconsin trap rock. Work was commenced by the contractor, the Bryant Asphalt Paving Co., of Waterloo, Iowa, October 1, 1917, and discontinued October 27 on account of cold weather, at which time 7,360 linear feet of surfacing had been laid. The materials and workmanship were unusually good and the work appears to be in fine condition. The contract price for the pavement was $1.62 per square yard, exclusive of the cement, which was furnished by the county. The cement cost $1.90 per barrel, or 61 cents per square yard of pavement, making the total cost of pavement, $2.23 per square yard. This does not include the cost of grading and drainage structures.

Showing materials for concrete distributed on road bed and manner of handling same to mixer. Iowa Federal Aid Project.

From hundreds of thousands of American farms, in answer to the call of their country and in obedience to the law of their country, American boys have gone and to-day are fighting side by side with hundreds of thousands of American boys from the cities and towns of the country, confronting danger and death.

The duty of us who remain at home in safety to afford the means to make these boys powerful and victorious is a most imperative one.

Buy Liberty Bonds and furnish them with the sinews of war.

RHODE ISLAND'S PROJECT.

The project statement for Rhode Island project No. 1 was mailed April 20, 1917. Notice that the project had been approved was received from Washington June 1. The plans, specifications contract, and bond were then prepared and sent to Federal District Engineer Miller. The site of the work was inspected by Mr. Miller in company with the State engineers June 26. The project agreement was executed September 13. Advertisements for the work involved appeared October 11 and proposals were opened October 26. The contract was awarded November 7 at a price approximately $2,000 less than the estimated cost of the items contained in the proposal. The clearing and grubbing were very nearly completed, and a small amount of excavation was accomplished before the weather stopped further work upon the contract. The type of construction adopted was bituminous concrete of the Topeka type.

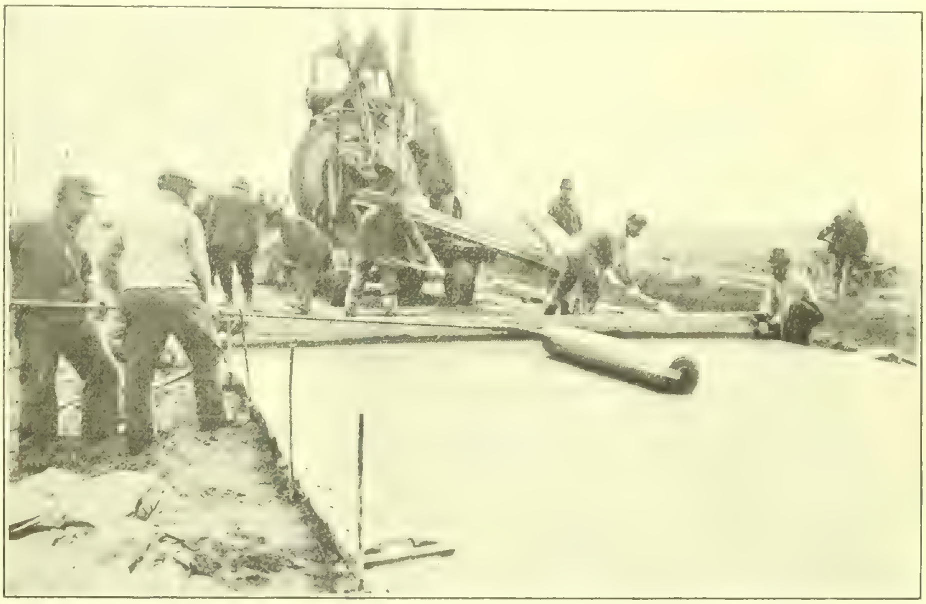
OHIO HAS TWELVE PROJECTS.

By

T. D. BRUNING, Chief Highway Engineer.

Under act of the legislature passed March 21, 1917, by which the State assented to the provisions of the Federal aid road act and authorized the State highway department to enter into contracts with the United States touching the construction and maintenance of rural post roads, all funds apportioned to the State must be expended upon the highways comprising the system of main market and intercounty highways.

So far the State of Ohio has submitted for consideration of the Federal authorities 12 Federal aid projects, for the first seven of which project agreements have been drawn. For three projects, known as Nos. 2, 3, and 7, the contracts have been let, although upon the first two no actual work of construction has been done. The type of pavement on project No. 2, which is an intercounty highway in Lucas County, is reinforced concrete and water-bound macadam. That on project No. 3, also in Lucas County, is of reinforced concrete. Work on No. 7, in Ashland County, was suspended on account of the severity of the weather after but little of the grading and culvert work had been done.



Showing manner of placing concrete on road bed and use of roller in removing water from surface of Iowa road.

Completed concrete paving in Iowa. Shoulders not finished.

VERMONT FEDERAL AID.

By

HERBERT M. McINTOSH, State Engineer.

The proposition of the Federal Government assisting the States in their effort to improve more important roads has met with general favor in Vermont. While the Federal work has not yet progressed beyond the paper stage in this State, we feel that we are getting organized, and will, under reasonable conditions, be able to show results the coming season.

Vermont's system of trunk lines or State roads consists of certain important highways which have been chosen by mutual agreements between the State and towns. So far the work on these selected roads has been done by joint action between the State and the several towns through which the roads pass. This cooperative work has resulted in developing a system of well-constructed earth and gravel roads, but with short stretches still in need of improvement. I make this brief statement, that the conditions under which we are working may be understood.

Careful consideration was given to the selection of our earlier Federal-aid projects. In making these selections, we did not alone consider the Government's requirements, but endeavored to offer such projects as would most improve our general road system, not forgetting local considerations. Our efforts resulted in submitting nine projects to the Federal department with the gratifying result that all were accepted.

These projects are short, varying from 0.7 to 2.8 miles, and are fairly well distributed over the State, and as a rule fill in gaps between improved sections on our most important selected roads. All nine projects have been surveyed, and plans and specifications completed for three of them, two of which have been submitted, and one accepted and agreement entered into. The plans and specifications for the remaining projects are in process of completion. These projects have a total length of 12.72 miles, and, as now contemplated, will be constructed of either gravel or macadam surface 18 to 21 feet in width with subdrain or stone base, where conditions require.

PROGRESS IN MICHIGAN.

By

J. H. BATEMAN, Office Engineer, Michigan State Highway Department.

Before the passage of the Federal-aid road act, roads in Michigan were constructed entirely by the various counties, townships, and road districts throughout the State. The State highway department's activity was confined largely to the distribution of State reward to the local communities building roads under specifications prepared or approved by the State highway commissioner. The State already had engaged in the construction of bridges on State trunk-line roads and was just beginning the construction of roads by special assessment under the provisions of a law passed by the 1915 legislature.

The Federal-aid law required that the State legislature, at its next regular session, assent to its provisions. The question had been raised as to the legality of the State building roads under the provisions of the State constitution, and to assure this, the 1917 legislature passed a joint resolution to refer a constitutional amendment to the people which would provide the necessary authority. The people voted favorably upon this amendment and the legislature then passed act No. 99, P. A. 1917, assenting to the provisions of the national law and outlining the procedure for building Federal-aid roads in Michigan. The essential features of the plan are as follows:

1. The State highway department, through the State highway commissioner, is authorized to take charge of all the management, engineering, building, and maintenance of Federal-aided roads and to enter into all contracts and agreements with the United States Government relative thereto.

2. Funds for building these roads are to be provided by the State and the local communities. The local communities are required to pay a certain percentage, depending upon their assessed valuation per trunk-line mile, according to the following table:

Assessed valuation per trunk-line mile	Per cent of cost to be paid by local community.
Below $100,000	25
$100,000 to $200,000	30
$200,000 to $300,000	35
$300,000 to $400,000	40
$400,000 to $500,000	45
Over $500,000	50

In each case the State pays the remainder of the cost from the State funds appropriated for this purpose and from such funds as may be allotted to each project by the Federal Government. The valuation per trunk-line mile of any county is determined by dividing the latest State equalized valuation by its allotted trunk-line mileage, computed on the basis of the number of surveyed townships in each county.

3. Localities in which Federal-aided roads are built are required to raise annually a sum equal to 3 per cent of the amount they contribute toward the cost of construction up to $100. The State pays the remainder of the cost of maintenance.

The Michigan plan, as described, presents several distinct advantages. The State trunk-line system was created by the 1913 legislature and since that time the improvement of a large mileage has been completed. But there are still a considerable number of gaps in the important roads of the State. These are largely in the poorer counties which cannot afford to build roads on a very extensive scale. They can, however, by paying, say, 25 to 40 per cent of the cost, go a long way toward completing the gaps in the trunk lines within their boundaries.

The various counties throughout the State appreciate the opportunity offered by the Federal-aid law and plans are being made quite generally which will take care of Michigan's apportionment for the five-year period.

About 32 projects are contemplated for the first three years' work. A summary of progress made to date is as follows:

Number of projects on which surveys have been made and plans started	24
Number of projects submitted	17
Number of projects accepted	10
Number of projects for which plans and specifications have been completed	6
Number of projects on which contracts have been let	2
Number of project agreements	1

All types of roads will be built under the five-year program, ranging from earth and gravel to concrete, brick, and asphaltic concrete. It is hoped that with the completion of this work most of the gaps in the trunk-line system of the State will be filled in.

SOUTH CAROLINA.

Federal-aid projects in South Carolina have been approved by the State highway commission and the Secretary of Agriculture for work in the following counties: Richland, Spartanburg, York, and Chesterfield. Greenville project will be approved by the Department of Agriculture as soon as detailed plans are completed.

It is planned to submit for approval projects for work in the following counties during the period of

January 1 to July 1: McCormick, Cherokee, Chester, Marion, Horry, and Union.

Projects for work in the following counties will be taken up when the 1919 Federal-aid apportionment becomes available: Clarendon, Bamberg, Chesterfield, Lancaster, Dorchester, Newberry, Lexington, Orangeburg, Darlington, Horry, and Pickens.

NEBRASKA.

History will repeat itself if the five-year program of State Engineer Johnson, of Nebraska, is carried out, as several stretches of roadway in his program received Government aid in Territorial days when Nebraska was considered but little better than Indian country. By an act of Congress of February 17, 1855, the construction of a "Territorial road from a point on the Missouri River (opposite the city of Council Bluffs, Iowa) in the Territory of Nebraska to new Fort Kearney in said Territory" was authorized. This road was laid out from the now city of Omaha to Fort Kearney, and the original location, made in 1855, has been followed closely in the counties traversed. Substantial improvements no doubt will be made on this historical "Military Road." Another road was authorized by Congress on March 3, 1857, and $30,000 appropriated for its construction. According to a map published in Morton's History of Nebraska, it paralleled the Missouri River from near the mouth of the Platte River to near the mouth of the Niobrara River, passing through Omaha, Fort Calhoun, and Tekamah the present route of the George Washington Highway through this section.

Federal Aid Act Interpretations.

IN connection with the administration of the Federal aid road act questions arise constantly which involve interpretations of the act and decisions as to policy. Among these the following may be cited:

Funds in States Prohibited from Engaging in Internal Improvements.

In such States as are forbidden by their constitutions from engaging in internal improvements, it was determined that the counties must raise the full amount necessary to be raised to entitle the State to its apportionment before cooperation can be undertaken.

What Constitutes Expenditure:

The period for which the funds apportioned to a State shall be available for expenditure is fixed by section 3, which also provides for a reapportionment of any balance unexpended at the close of such period. The question arose as to what constitutes expenditure within the meaning of the act. Inasmuch as the negotiations between the State highway department and the Secretary of Agriculture for cooperation under the act consist of the submission by the highway department of a project statement; its consideration and approval by the Secretary of Agriculture; the filing of plans, specifications, and estimates by the highway department and their approval by the Secretary of Agriculture; the execution of project agreement by the highway department and by the Secretary; and the execution by the secretary of a certificate approving the plans, specifications, and estimates, by which the Federal funds allotted to the project are set aside in the Treasury, thus definitely obligating the Government to pay the amount of funds so set aside, it was determined to be the view of the department that the money is expended within the meaning of the act at the time the secretary executes the project agreement. If at the end of the period during which the apportionment for a particular fiscal year is available the State should not have entered into project agreements with the Secretary of Agriculture in an amount sufficient to consume the entire apportionment for that particular year, the balance would be apportioned in accordance with the terms of section 3 of the act.

The sooner the irresistible might of this great Republic is organized and put into full action the sooner the war will end. Every dollar invested in Government securities works to shorten the war, to save the lives of American soldiers and sailors.

Availability of Balances that Occur on Projects:

It may occur frequently that after the construction work is completed and final payment is made on a project there will remain a balance of the funds set aside in the Treasury for that particular project. Therefore it was important to determine whether such balance would be available for application on other projects in the State and also whether it would be applicable on such other projects without the project agreement therefor being executed prior to the expiration of the period allowed for the expenditure of the apportionment from which the funds were originally set aside in the Treasury. After careful consideration it was determined that such balances may be credited to the apportionments of the particular State available during the year when it is found that such balances have occurred and may be applied on other projects, but to become nonavailable at the end of the period when the then available apportionments become nonavailable. It was determined also that the liability incurred by the Government on account of an individual project can be set up against any funds apportioned to the State which are available for payment instead of against the apportionment for a specific fiscal year.

Mileage should not be Indefinite:

Closely related to the foregoing questions there arose the alternative suggestion of specifying in the project statement and in the project agreement an approximate instead of an exact mileage. However, it was deemed inadvisable to have the project statement and the project agreement specify an indefinite mileage. In cases where it may be found desirable to alter the mileage stipulated in the project agreement, it can be done by a modification of the agreement.

Use of Federal Funds on Roads in Indian Reservations:

The question as to whether or not the Federal aid road funds may be used in the construction of rural post roads on Indian reservations is of importance to those States in which such reservations are located. Consideration was given to this matter and it was determined that there is nothing in the act itself to indicate any intention on the part of Congress to exclude from the benefits thereof rural post roads within Indian or other reservations and that the question was one for determination from an administrative standpoint.

Convict Labor or Force Account—Payments:

The practice in many of the States is to do a large portion of road work by convict labor or force account. In some few States the law even prohibits the letting of such work to contract. Therefore it was necessary to arrive at a basis on which payment of Federal funds would be made on projects in such instances, the basis of payment finally determined upon being as follows:

(1) Where in road construction, a State calls for bids and bidders have the option of using free or convict labor and each bidder has equal opportunity to secure convicts and the lowest responsible bid is to be accepted, the department is willing to enter into a project agreement on the basis of such bid, without further reference to the terms on which the convict labor may be secured by the contractor.

(2) Where the State has the option of doing the work itself with convict labor and is in a position to call for bids, the department is willing to proceed with a project on the following basis: It will assent to the State's proceeding with the work on the assumption that it will not cost more than the lowest responsible bid and that the department will be expected to pay not exceeding fifty per cent of the actual cost, but the convict labor shall not be reckoned in the account at more than the current local rate of wages specified in the project agreement.

(3) In rare cases where bids are not received, or where they are clearly unreasonable, if free labor is employed by the State it shall not be reckoned in the account at more than the current local rate of wages specified in the project agreement.

(4) Where the State is prohibited by law from awarding a project to contract or where conditions are such as to make it impracticable or unduly expensive to do the work by contract, and the State highway department desires that it shall be done by day labor or convict labor, payment may be made by the Federal Government on the basis of the labor and materials which have been actually put into the road. The value of such labor and materials in such cases, and also in cases arising under paragraphs (2) and (3) if so provided in the project agreement, shall be determined on the basis of the unit prices set forth in the estimate as approved by the Secretary.

Restrictions on Use of Convict Labor:

In further reference to the matter of convict labor, it was determined that the Executive order of May 18, 1905, prohibits, in the construction of roads under section 8 of the Federal aid road act, the use of convict labor (*a*) by a contractor where the road is to be constructed by contract; or (*b*) by a county where a road under section 8 is to be constructed by day labor and the local authorities agree to contribute labor as their part of the cooperation.

Projects May Be Approved and Agreements Entered Into After Certificate of Apportionment Filed:

After considering the question as to whether or not after the certificate of apportionment for any fiscal year has been filed, and prior to the beginning of the next fiscal year, projects may be approved and project agreements entered into, it was determined that it could be done, provided no part of the road for which Federal aid is contemplated under such agreement should be constructed prior to the beginning of the fiscal year for which the appropriations involved were made, and provided further that no project statement should be approved or project agreement be entered into involving the appropriation for any fiscal year prior to the filing of the certificate of apportionment for that year.

AMENDMENTS TO REGULATIONS.

The Rules and Regulations of the Secretary of Agriculture for carrying out the Federal aid road act, as issued September 1, 1916, and revised April 28, 1917, have since that date been further amended as follows:

Amendment No. 3 to the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the Federal aid road act, issued September 1, 1916.

Under authority conferred upon the Secretary of Agriculture by the act of Congress approved July 11, 1916, entitled, "An act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes" (39 Stat., 355), known as the Federal aid road act, I, D. F. Houston, Secretary of Agriculture, do hereby amend Regulation 5, section 8, of the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of said act, promulgated September 1, 1916, as amended by Amendment No. 2 under date of January 24, 1917, to read as follows:

For all projects for which statements are submitted after September 30, 1917, standards governing the form and arrangement of plans, specifications, and estimates will be hereafter prescribed and promulgated by the Secretary.

Done at Washington this 23d day of April, 1917.

Witness my hand and the official seal of the United States Department of Agriculture.

(Signed) D. F. HOUSTON,
Secretary of Agriculture.

Amendment No. 4 to the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the Federal aid road act, issued September 1, 1916.

Under authority conferred upon the Secretary of Agriculture by the act of Congress approved July 11, 1916, entitled "An act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes" (39 Stat., 355), known as the Federal aid road act, Regulation 6, section 1, of the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the said act, promulgated September 1, 1916, and amended by Amendment No. 1, dated October 18, 1916, is hereby further amended to read as follows:

REGULATION 6. *Project agreements.*

SECTION 1. A project agreement between the State highway department and the Secretary shall be executed, in triplicate, on a form furnished by the Secretary, previous to commencement of the construction of the project, except that as to projects for which project statements were approved prior to August 15, 1917, payments may be made on account of work done prior to the execution of the project agreement, if such work can be adequately inspected as required by the act.

Done in the District of Columbia this ——— day of August, 1917.

Witness my hand and official seal of the United States Department of Agriculture.

(Signed) D. F. HOUSTON,
Secretary.

Amendment No. 5 to the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the Federal aid road act, issued September 1, 1916.

Under authority conferred upon the Secretary of Agriculture by the act of Congress approved July 11, 1916, entitled "An act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes" (39 Stat., 355), known as the Federal aid road act, Regulation 6, section 1, of the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the said act, promulgated September 1, 1916, and amended by Amendment No. 1, dated October 18, 1916, and further amended by Amendment No. 4, dated August 31, 1917, is hereby further amended to read as follows:

REGULATION 6. *Project agreements.*

SECTION 1. A project agreement between the State highway department and the Secretary shall be executed, in triplicate, on a form furnished by the Secretary, previous to commencement of the construction of the project, except that as to projects for which project statements were approved prior to November 1, 1917, payments may be made on account of work done prior to the execution of the project agreement, if such work can be adequately inspected as required by the act.

Done in the District of Columbia this 8th day of November, 1917.

Witness my hand and official seal of the United States Department of Agriculture.

[SEAL.] (Signed) D. F. HOUSTON,
Secretary.

Amendment No. 6 to the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the federal aid road act, issued September 1, 1916.

Under authority conferred upon the Secretary of Agriculture by the act of Congress approved July 11, 1916, entitled "An act to provide that the United States shall aid the States in the construction of rural post roads, and for other purposes" (39 Stat., 355), known as the Federal aid road act, Regulation 5, section 7, of the Rules and Regulations of the Secretary of Agriculture for carrying out the provisions of the said act, promulgated September 1, 1916, is hereby amended to read as follows:

REGULATION 5. *Surveys, Plans, and Specifications and Estimates.*

SEC. 7. When plans, specifications, and estimates have been approved by the Secretary, no alteration thereof shall be made without his approval, except that minor alterations which will not involve an increase in the cost of the project to the Federal Government may be made with the approval of the Director of the Office of Public Roads and Rural Engineering.

Done in the District of Columbia this 15th day of November, 1917.

Witness my hand and official seal of the United States Department of Agriculture.

[SEAL.] (Signed) D. F. HOUSTON,
Secretary.

Amendment No. 1 to the Standards Governing the Form and Arrangement of Plans, Specifications, and Estimates for Federal Aid Projects as prescribed by the Secretary of Agriculture and promulgated April 28, 1917.

In accordance with the requirements of Regulation 5, section 8, as amended, of the Rules and Regulations of the Secretary of Agriculture, issued September 1, 1916, for carrying out the provisions of the act of Congress approved July 11, 1916 (except section 8 thereof), entitled, "An act to provide that

The test is on—does German autocracy breed better men than American democracy?

the United States shall aid the States in the construction of rural post roads, and for other purposes" (39 Stat., 355), known as the Federal aid road act, the paragraph entitled "Scales," on page 6, and the paragraph entitled "Cross Sections," on page 7, of the Standards Governing the Form and Arrangement of Plans, Specifications, and Estimates for Federal Aid Projects, prescribed by the Secretary of Agriculture and promulgated April 28, 1917, are hereby amended to read, respectively, as follows:

Scales.

The plan shall be drafted to a scale of 1 inch=50 feet or 1 inch=100 feet, at the option of the State highway department, with the following exceptions: Where the proposed location passes through a plains country or where the contemplated improvement consists only of surfacing without changes in the existing grade or alignment, sections not less than 2 miles in length may be drafted to a scale of 1 inch=400 feet, provided there are relatively few topographic features, such as fences, pole lines, buildings, etc., to be shown.

The profile shall be drafted to the same horizontal scale as the plan. Where the horizontal scale is 1 inch=50 feet or 1 inch=100 feet the vertical scale shall be 1 inch=10 feet, and where the horizontal scale is 1 inch=400 feet the vertical scale shall be 1 inch=20 feet.

Cross Sections.

Cross sections shall be taken at intervals not exceeding 100 feet, with the following exceptions: Where the grading is relatively light and uniform in section or where only surfacing is contemplated, cross sections will be required only at such intervals as will be necessary to show the character and extent of the intended work.

The cross sections shall be plotted to a scale of 1 inch=5 feet vertically and horizontally. They should be plotted from the bottom of the sheet upward and so as not to interfere unduly with one another. Either the lower side or the right-hand end of the sheets may be used as the bottom in plotting. The cross sections should show the ground surface and the templet lines for the proposed construction, each being marked with its station location, "grade line" elevation, and cross-sectional area or the yardage between sections. Any desired additional information may be shown.

Done in the District of Columbia this 10th day of December, 1917.

Witness my hand and official seal of the United States Department of Agriculture.

[SEAL.] (Signed) D. F. HOUSTON,
Secretary of Agriculture.

FOR STRONG MAINTENANCE POLICY.

Pennsylvania has declared for a strong maintenance policy. The State commissioner determined that roads already built must be maintained adequately at all costs. The roads in certain sections of the State suffered from cloudbursts, freshets, slips, slides, and in this last winter from excessive snowfalls, all of which factors combine to increase the maintenance costs in the particular localities affected. The main trans-State roads are being subjected to greatly increased heavy motor truck traffic and this adds to the problem of maintenance.

Lets $1,254,998 Contracts in a Season.

In the 1917 season Pennsylvania let highway construction contracts aggregating $1,254,998.20 for road improvements in 15 counties. A large proportion of these contracts were let after the 1st of September.

HIGHWAY WORK IN WISCONSIN.

(Continued from page 18.)

6,000 miles of road on the system of prospective State highways. This includes the construction of approximately 10,000 concrete culverts and approximately 1,500 State aid bridges. In addition the commission has designed and supervised the construction of a still greater number of bridges built by the towns and counties, toward which the State made no contribution in money.

The State highway law will continue in operation with an anverage annual expenditure of two and one-half million dollars and will serve to increase the work done on the State trunk highway system and to improve other highways which, while important from the standpoint of local communities, are not so important from the State and national standpoints.

Little need be said about the work being done under the township system. The inefficiency and wastefulness of township road work are proverbial, but there are indications that the influence of systematic improvements made under the State aid system is beginning to cause the introduction of the same methods in the township work, and it is believed that when the Federal aid construction is fully under way that this will have yet greater influence. The maintenance provision to be instituted by the State under its trunk highway law has met with wide appreciation. Several of the counties already have arranged to institute the patrol system on county roads not included in the State trunk highway system, and it is altogether likely that the results will cause a revolution in the past methods, even in town road work.

Those who expect too much are sure to be disappointed, and no one expects the immediate road millenium in Wisconsin, but we believe that the system now in force in the State, well financed as it is, and sure to be better financed when normal times return, will effect the solution of the road problems of the State and that the improvements made will soon put this State in the front rank of good roads States in the Middle West.

The greater part of the world now looks to America as its chief hope of safety from tyranny and oppression. Our mission is worth the devotion, the sacrifice, the labor of every American.

BUY LIBERTY BONDS.

SAVING FUEL IN HIGHWAY WORK.

BY
GEORGE E. LADD, Economic Geologist, Office of Public Roads and Rural Engineering.

WHEREVER coal is burned for steam generation, fuel economy is important from a business standpoint. With the country suffering from coal shortage, and the need for coal for war purposes increasing steadily, it becomes a patriotic duty to avoid waste in every way possible in our consumption of coal. In connection with highway construction steam is used at quarry plants in driving road rollers, at municipal paving plants and in the manufacture and application of bituminous materials. Altogether the amount of coal used in these plants is large, and the amount of waste notable.

This is written in the hope that every man in charge of a coal consuming steam-power unit used for quarrying, stone crushing, and road construction will not only do his "bit," but his best to cut down the waste of coal. This can be done by eliminating steam leaks; by keeping the boiler and furnace in the best possible condition; and by proper attention to "firing" and draft regulation.

Knowledge of his plant and his duties are vitally important in a fireman. To handle a furnace and boiler properly requires expert knowledge and considerable experience. Make sure that your fireman possesses such knowledge and experience and puts into practice the following suggestions:

Keep track of the coal burned even in your smallest steam-producing units and see that none is wasted. Obviuosly, coal is wasted when steam is wasted. Stop the steam leaks. A recent trip to quarries in the Eastern States where crushed stone is being used showed an amazing amount of carelessness in this respect. Valves and the pipe lines to drills, engines, and asphalt heaters were leaking badly in the great majority of quarries.

Mud or scale is not only ruinous to boilers, as well as dangerous, but leads to coal waste. Keep the boilers clean. Get the best water possible for boiler use. Bad water may produce erosion, incrustation, priming, or the formation of a heavy precipitate. Corrosion is the eating away of the shell and tubes, and is caused by acid water, carbon dioxide and oxygen dissolved in water, grease (from condensed steam), organic matter, or chloride or sulphate of magnesium. Incrustation is the formation of scale on shell and tubes of boiler, and may be caused by mud, clay, or other sediment in water; salts in solution, as bichloride of lime, magnesium or iron, and sulphate of lime. Priming is the violent foaming of the water in the boiler, often carrying it over into the steam lines. It may be due to sewage in water or to a large quantity of carbonate of soda. Any one of these troubles leads directly or indirectly to waste of fuel.

If the water be troublesome, there is no use in trying to remedy it with "boiler compounds" *unless they are made for the water in question*, and the only way to find out what is needed is to have a chemical analysis made, and a compound prepared which is suitable for that particular water.

REMOVAL OF SCALE.—There are two kinds of scale: (1) A hard, adherent scale, due to sulphate of lime in the water; and, (2) a soft, powdery scale, due to carbonates of lime, magnesia, or iron.

The soft scale can be removed by blowing off and washing thoroughly with stream of water when cleaning.

Kerosene has been used with good results in loosening the hard scale. Scale can be removed to some extent by acids, such as hydrochloric, acetic, and tannic, but they also attack the iron, may cause damage, and are not to be recommended.

Heavy scale must be removed from the sheet by a hammer and chisel, but it is impossible to clean it from tubes in this way. A good flue rattler will remove thick, hard scale from tubes, and, if handled properly, will not injure them.

WATER HEATER.—A big saving of fuel can be made by heating the water before it enters the boiler with exhaust steam from the engines. For every 11° feed water is heated, there is a saving of one per cent of fuel. If bad water is being used an additional saving is effected by the elimination of much sediment and scale-forming minerals *in the heater*, by installing trays and a filter in it.

SELECTING BOILER.—If possible use only such a boiler as, with easy firing, moderate draft, and ordinary fuel, will develop one-third more "commercial horsepower" than is required by the work inhand.

Following is a list of duties of firemen, with notes and suggestions:

1. Know all the pipe connections, locations of valves, unions, and the easiest and best methods of reaching them on an emergency.
2. Know the principles of firing, and the method which gives best results.

The problem of the American Treasury is the problem of the American people. The Treasury is but the medium, the instrument, of the Nation to raise the means to carry on the Government and to bring this war to a victorious conclusion.

BUY LIBERTY BONDS.

The following are offered as suggestions and have been found to embody the best practice for hand-fired, stationary boilers:

(*a*) Fire evenly and regularly, that is, put on approximately the same amount of coal each time and at regular intervals of time.

(*b*) Place the coal where needed and keep fires in such condition that a moderate amount of coal (two to four shovelfuls) is sufficient.

(*c*) Keep fires clean and bright all over.

(*d*) Break up large lumps if they are used.

(*e*) If coal contains much volatile matter, the coking method often is used instead of (*c*). The coal is banked at the door and kept bright behind the bank, thus causing the bright hot fuel to burn the volatile matter in the coal. This is pushed back as necessary before putting on fresh fuel.

(*f*) Keep fires free from holes. Attention is called especially to sides of the furnace and rear end.

(*g*) Regulate draft and air supply to suit working conditions.

(*h*) Watch the gauges.

(*i*) Do not level or stir fire if not necessary.

(*j*) Thickness of fire will depend on draft and amount of smoke. Regulate this to give the best conditions.

(*k*) Do not allow ashes or clinkers to accumulate on walls or in combustion chamber.

(*l*) Clean fires when necessary. If let run too long air spaces in grates clog up.

3. See that the water is at proper height and kept at that height all the time. Do not rely on water gauge, but try the gauge cock.
4. Keep even and uniform steam pressure.
5. Gauge cocks and water glasses should be kept clean. The water gauges should be blown out frequently and glass and passage to gauge kept clean.
6. Safety valve should be tested at least once every day, preferably in the morning, to see that it acts freely.
7. The pressure gauges should stand at zero when the pressure is off, and show correct reading when the boiler is popping off. The steam pressure gauges should be tested once every three months.
8. See that the feed pumps or injector are in duplicate and both in good repair, and either capable of doing the required work. All machinery needs repairs occasionally

It is bad to put cold water in boiler. If it is used an injector should be employed.

If hot water is used see that feed pumps are below the supply, otherwise pumps will give trouble.

A little hot-water packing, rubber valves, and piston and gland packing always should be kept with tools, and these should have a specific place, and always be kept there ready for use.

9. The check valve should be kept clean and be watched to see if it is working when water is being pumped into the boiler.
10. Examine fuse plugs when cleaning boiler and scrape both ends to clear surface.
11. Keep all holes in "setting" carefully stopped, and make all air enter through grates.
12. See that blow-off does not leak, and blow off frequently if water is muddy.
13. Do not empty boilers if brick work is very hot.
14. Keep boiler clean both inside and outside. Conditions of water will regulate time of cleaning, which may be from every day to intervals of not more than two weeks.
15. Keep dampness away from outside of boiler.
16. See notes above about importance of keeping out scale, and how to remove it from flues. The saving in fuel makes it pay to have flues taken out occasionally, cleaned, rewelded and and put in again. Bad scale on shell causes burning and cracking of sheet.
17. The bridge and furnace walls should be kept in good condition.
18. The grates should be kept in good condition, and for poor coal extra large rather than small grate area is better. If too large, the sides can be covered with layers of brick. If shaking grates are used, be careful to see that the grates go back level after shaking.
19. If a heater is used it may get dirty faster than boilers, and needs cleaning regularly.
20. A small leak about the man head soon destroys the planed surface, and makes it difficult to keep tight with any gasket. If graphite is mixed with oil and put on the gasket, it will make it last longer and prevent sticking.
21. If fire-brick lining to the boiler front is not kept in good condition, warped and cracked fronts and doors soon will be the result.
22. Steam leaks should not be permitted, because steam under pressure travels with an enormous velocity, and small leaks discharge many pounds of steam in a day. Many leaks mean many horsepower lost.
23. Ash pits should be water-tight and water should be kept in them at all times. They should be cleaned out thoroughly when fires are cleaned, and oftener if necessary.
24. If the draft is poor an accumulation of soot or ashes will make it worse. Breaching and stack connections should be kept tight.
25. The tools—shovel, coal pick, rake, two-pronged hook, leveler, and long-handled scraper—should be kept in good repair and in regular place.
26. In order to know the results or value being obtained from the fuel, records should be

kept, and the following data is necessary and valuable:

(*a*) The character of fuel being used.

(*b*) The amount of coal burned per day or shift. This can be weighed or measured.

(*c*) To know the area and condition of grate surface and calculate the pounds burned to square foot of grate surface per hour.

(*d*) The amount of ashes made per day or shift. This can be measured or weighed. It would be a help to note color and character of the ash, amount of clinkers formed, and amount of coal or coke that goes out with the ash.

(*e*) Weigh or measure the amount of feed water used per day or shift.

(*f*) Take reading occasionally of temperature of the feed water.

(*g*) Calculate at some time, and put down as a permanent record, the heating surface of each boiler.

(*h*) Divide the total heating surface into pounds of water used each hour, and find out the pounds evaporated to the square foot of heating surface.

(*i*) Note reading of steam gauge hourly unless a recording gauge is used.

(*j*) Determine the amount of draft there is, if a draft gauge is available.

(*k*) Determine the amount of air being used and compare the pounds of air used to the pounds of coal. This is not simply or easily done, because it requires special apparatus. It gives valuable information because it shows whether the coal is being completely burned or not; shows the presence of bad leaks and helps to show method necessary in order to correct trouble.

(*l*) The conditions of boilers and grates should be noted each shift, and made a matter of *record* because it may save a big expense in the future.

(*m*) Note the thickness of fire that seems to give the best results. See how the smoke from this thickness compares with amount of smoke made at other thicknesses.

27. If a boiler stand unused, it should be emptied and dried if possible. If not subjected to freezing weather it may be filled full of water to which a little common soda (washing soda) has been added.
28. Cleanliness about boilers is as necessary as it is in the boiler room.
29. *In case of emergencies:*

(*a*) In case of low water cover fire with dirt or ashes, or, if these are not handy, cover thoroughly with fresh coal. Draw fire when it can be done without increasing the heat. *Do not turn feed water in, start or stop engine, or lift safety valve until fires are out and boiler cooled.*

Good business as well as patriotism urges support of the Government in its financial needs, and to no class of Americans more than to the farmers of the Nation whose own welfare is indissolubly bound up with that of the United States Government.

BUY LIBERTY BONDS.

(*b*) Should boiler show signs of buckle starting, it is an indication of scale and that sheet is too hot. A boiler may be pulled through the shift by watching it carefully, and firing light as possible, otherwise buckle will get larger. If boiler sheet is cleaned at end of shift, and mud pan put over the buckle, it can be used until arrangements are made for hammering it back.

(*c*) If a boiler has a patch a bad leak may come at any time, but if boiler is needed badly it can be used, although it is much harder to fire, and leak may put fire out in places. When it is being cleaned and is cool it may be examined. If leak is due to loose rivet the old one may have to be removed and new one driven, or it may be calked with proper calking tool, or it may have to be chipped and calked. Sometimes patent cenents are put in the crack if calking does not hold. Chipping and calking tools should be kept in good condition, and used by a man who has had experience or helped to make a repair.

Our endeavor should be to lose as little heat from the combustion of fuel in the furnace as possible, to change the water into steam in the most efficient way, to convey the steam to our engine with the least loss of heat possible, and to convert the greatest amount of it possible into *mechanical energy*. These problems are accompanied by that of the proper care of all the apparatus used in the above processes.

BRIDGE BUILDING IN MINNESOTA.

In 1917 there were 124 large bridges built on Minnesota State roads and it is believed it will be necessary to build approximately twice that number in 1918. There were 1,112.67 miles of road graded to permanent grade line and 314.2 miles surfaced with gravel, in addition to 458.2 miles of grading not entirely completed and 98.7 miles of graveling still under contract and not quite completed.

WILL BUILD NEW TYPE OF BRIDGE.

Six new bridges will be built on the St. Paul to Duluth highway this year, according to J. T. Ellison, bridge engineer, Minnesota highway department. One of the bridges will be a type entirely new in highway and bridge construction in Minnesota. It will be built on Federal aid project No. 1 at Pine City and will have 20-foot spans supported upon concrete piles. The concrete piles will be driven with equipment much the same as used in driving timber piles. The bridge will be 400 feet long with an 18-foot roadway and will be one of the best constructed bridges in the Northwest.

STATE HIGHWAY DEPARTMENTS AND LABOR.

By

C. J. BENNETT, State Highway Commissioner, Connecticut.

AT a time when the country is disturbed by labor conditions it is of especial interest to the State highway official to consider his place in the general scheme of organization and determine for himself how to work out his salvation. The labor question presents itself to one of us in two different ways: First, labor employed by the contractor; and second, labor employed directly by the department.

The question of securing labor by the contractor will, in the opinion of the writer, make it unlikely that satisfactory bids for road construction on a unit basis, will be received during the present crisis, and some definite system of awarding contracts on cost plus a fixed profit or cost plus a percentage must be worked out. Of course, if either method is adopted, the first requisite will be the selection of a thoroughly reliable and competent contractor so that the fixed profit or percentage will be the only outlay by the department which does not go directly into the purchase of material or remuneration of labor. By adopting some such method as this, it will of course, be possible to take care of fluctuations in the labor market without injustice either to the state or to the contractor; and with a reliable contractor receiving a fair profit, of which he is sure, the general result should be that roads will cost a fair amount.

One difficulty that arises along these lines, however, is the fact that if the State highway official is paying a fixed profit or percentage, he has more opportunity to interfere with the organization and operation of the work than in the case where the contractors operate on the unit price basis, and while he may be fully as competent to organize the job as the contractor, the conflict of authority may tend to cause confusion in the proper completion of the work. Consequently, in contracts of this nature, the organization of the job should be worked out thoroughly before the work is started; that is, the equipment to be used should be determined and the maximum number of men and teams decided upon. The department should employ a competent timekeeper to check up the accounts on the job so that no mistakes will occur.

Given reasonable department officials, honest and competent contractors, this method of carrying on highway construction at this particular time should give good satisfaction.

With regard to the employment of labor directly by the department, the work done, of course, divides itself into the items of construction and maintenance. It may be possible and, in fact, satisfactory, for State highway departments to carry on construction work with their own forces and equipment. There is some element of unfairness in this where a department has been accustomed to receive bids from contractors for work of this character, but in this crisis, it seems that we are justified in taking almost any steps to carry on the work necessary and, therefore, in order to avoid difficulties between contractors and the department, it will be necessary, in many cases, to organize construction forces for the carrying on of road building.

Securing labor for this purpose will not be an easy matter, especially where the work is to be done in the vicinity of centers of population. It will be difficult to maintain a steady working force, because of advantageous offers from outside sources. The rate of wages for maintenance work paid to the regular employees should be increased to such an amount as to make the work attractive to them.

At this particular time, every attempt should be made to utilize labor from sources which are not ordinarily available. This, of course, refers to the use of convicts or interned alien enemies. The use of convicts for road construction and maintenance has been discussed thoroughly from time to time and many objections have been raised, but it would seem from experience gained in this section that prisoners from the jails and penitentiaries could be used with success, particularly if they are paid a reasonable amount for their services. No attempt should be made to get something for nothing. The men should be treated not as convicts but as men. Of course, the use of labor of this class is restricted to sections where they do not come in touch with the ordinary population, since their freedom is restricted. They may be kept in camps or returned to the prison at night, although it is the opinion of the writer that every effort should be made to disconnect them from the institution to which they have been sentenced, during the time they are at work on the roads. The endeavor should be to make them forget their imprisonment and to realize they have become useful members of society.

With reference to the use of alien enemies, the number available is comparatively small, but may increase as the war goes on. The treatment of the alien enemies, of course, is a military matter, and the damage done by their escape would be greater than in the case of the ordinary convict. Nevertheless, at this particular time, we must endeavor to use every possible instrument to carry on our work. Ordinary methods cannot be used. Extraordinary efforts must be made to utilize not only the usual supply of labor but to augment this supply by recourse to the prisons and reformatories, and even the enemy alien camps.

Convict Labor on Highways Success in Rhode Island.

By

I. W. PATTERSON, Chief Engineer.

WE IN Rhode Island suffered more or less during the past year from the unusual conditions surrounding the labor situation. As a matter of fact, however, the conditions never were as serious as we anticipated early in spring. The rate of wages paid labor was higher than normal and the efficiency of labor was lower than usual in many cases, but at no time did the labor situation become serious enough to cause the stopping of road work which was in progress. We considered the work of repairing sections of our main through trunk lines, which were at certain seasons almost prohibitive to travel, of such great importance in view of the commercial value of these routes at this time, that the higher cost of repair occasioned by the labor situation was deemed insufficient to warrant the stopping of work.

An act allowing the use of convicts upon State road work was passed by the general assembly early in 1917. This act provided for our use of convicts by agreement with the State penal and charitable commission. Under this act the rate of allowance for the service of convicts was to be agreed upon between the highway department and the penal and charitable commission. The guarding, feeding, and clothing of the convicts was to be taken care of by the penal commission and the highway department was to supervise their work upon State roads.

Two camps were established and the convicts from these camps were employed in building bituminous macadam State roads during a large part of the past construction season. For a matter of two or three weeks the fact that many of the prisoners were unused to hard manual labor and had never had experience in road work affected the efficiency secured. Gradually, however, the efficiency increased.

At the beginning of the work by convicts $1.50 per workingman day of nine hours was allowed for their services. Later the penal and charitable commission demanded an allowance of $2.25 per day for the services of each convict employed upon the work, no time to be deducted for periods when, because of inclemency of weather or for other reasons except the incapacity of the prisoners, no work was done. Although this department felt that this demand was not wholly justified, the demand was granted in order that the work undertaken by the prisoners might be carried to completion so that this experiment might receive a fair trial.

The results secured varied. The convicts from one camp built a road which was first class in every detail, while the convicts from the other camp produced results which were disappointing as far as quality is concerned. The road which was excellently built, furthermore, cost much less as far as unit costs are concerned than did the inferior road. Differences in housing facilities, in the personalities of the guards over the convicts, in the capabilities and energy of the camp cooks, and in the character of the prisoners themselves, were reasons, to our minds, for such a difference in the results secured. Changes in the personnel of the gang whose work was not particularly satisfactory, by reason of the expiration of sentences and the return of prisoners to the jail for infractions of rules, also had a disorganizing effect, which resulted in a lessening of efficiency.

Our experience with convict labor has convinced us that excellent results are possible by the use of prisoners for road work. We are able to perceive faults, both with our law which makes possible our use of convict labor, and also with some of the details of carrying out of the work. We heartily approve of convict labor for road work, both on account of the physical and moral benefits derived by the prisoners, and on account of the aid to the labor situation which the use of convicts brings about.

VERMONT.

By

S. B. BATES, State Highway Commissioner.

The labor situation in Vermont as to highway work is somewhat different from that in most States. The highway improvement work is taken up with each town each year and certain sections determined on for improvement. This has resulted in the construction of limited projects which could be taken care of with local labor, so that the question of assembling a large force on one job has not yet come up—the number of men engaged in any one project seldom exceeding 20.

When practical, construction work has been taken up in many of the towns in that part of the season which interfered the least with agricultural work. Because of this it has been possible to utilize labor that during other parts of the year were employed locally.

At this time there is a great scarcity of labor for the farms—in fact, in many of the communities a large part of the labor force has gone into the service, or sought industrial employment. The possibility of obtaining sufficient labor for highway work is very uncertain.

Not much has been done in the way of employing prison labor, although the matter has been discussed. Some work was done last year with labor from the house of correction. This plan is receiving careful consideration at the present time.

COMING PUBLICATIONS.

The Commercial Sizes of Broken Stone Aggregates: By F. H. Jackson, jr., and C. W. Mitman.

This article will appear in the next issue of Public Roads. It gives the results of the study of about 90 commercial stone-crushing plants located in the New England and Middle Atlantic States made in the summer of 1917. Those features of crushing plant design and operation which bear directly upon the production of the actual sizes of the various grades of stone used in road construction are taken up separately and discussed in detail. Comparative studies are made also of the nomenclature used in designating stone sizes and of the actual sizes of stone produced under the requirements of the several State specifications.

Examples of the adverse conditions under which the crushed-stone operator is obliged to work on account of the fact that no uniform sizes of crushed stone exist and the reasons for these conditions are given. Means for alleviating and possibly eliminating them are proposed. On the basis of the information obtained, a series of standard crushed-stone sizes is offered tentatively for consideration, as is also a system of designating these sizes.

Highway Cost Keeping: By James J. Tobin and United States Engineer Economists; Reviewed by Halbert P. Gillette, Consulting Cost Engineer.

This department bulletin has a twofold object; to present in an elementary way, first, the principles of cost keeping; and, second, a practicable system of highway cost keeping.

A review of highway engineering literature will show that there is very little published relating to highway cost keeping as compared with that to be found in other fields of engineering endeavor. This is especially noticeable when highway cost keeping is compared with factory cost-keeping. An exhaustive study was made of the highway cost keeping systems at present in vogue. This study revealed the general absence of cost keeping on by far the greater portion of highway work. It was also discovered that a wide latitude existed in the interpretation of cost terms and comparable costs were almost nonexistent. In a number of instances cost-keeping systems well suited to specific cases were found, and from these systems valuable information was gathered, which has been incorporated in this bulletin.

The first part of the bulletin is devoted to the fundamentals of cost keeping. A short history of cost keeping is given, showing its development in the manufacturing industries. The elements of cost, labor, materials, plant and equipment, and general expense are discussed sufficiently to show their relation to highway costs. Particular attention is given to plant and equipment costs. The importance of considering cost of repairs, loss of time through idleness, and the fixed charges of depreciation, interest, taxes, and insurance is emphasized. A tabular analysis of cost, showing the cost elements as finally applied to highway operations is given. In order to obtain costs satisfactorily it is necessary to decide upon definite, determinable units of measure. A chapter on units of measure is included in the bulletin.

The second part of the bulletin deals with a system of highway cost keeping. The essentials of such a system are first discussed. Following this is given a classification of accounts based upon road parts and major operations. The object of this classification is to establish a definite connection between highway cost keeping and the ledgerized accounts of the highway organization. This classification of accounts is simple enough to be applicable to small highway organizations where only general costs are desired. It is capable of expansion so as to enable the recording of costs in great detail where desired. A cost-keeping code is given based on the classification of accounts and a classification of highway operations. The use of the code is illustrated by numerous examples. Forms suitable for recording costs in the field are included, as well as forms for compiling and reducing such costs to unit operation costs.

Typical Specifications for Bituminous Road Materials: By Prevost Hubbard, Chemical Engineer, and Charles S. Reeve, Chemist.

This publication presents the latest recommendations of this office on typical specifications for bituminous materials, which are intended to supersede all prior specifications for bituminous materials issued by the Office. It contains a total of 29 specifications, covering, respectively, oils for cold and hot surface treatment, tars for the same purposes, as well as for cold patching, oil asphalts, fluxed native asphalts and tar pitches for use in construction. They are based on the experience of the Office as well as the ability of the manufacturers to meet their requirements. Each specification is accompanied by a brief paragraph describing the general character of the material, the purpose for which it is intended, the method of using it, the type of road and the general condition for which it is best suited and the results which may be expected from its use. The bulletin contains an appendix in which recommended methods for sampling are given and also descriptions of the methods for making all tests to which reference is made in the specifications.

Small-Scale Production of Crushed Stone for Public Roads: By Geo. E. Ladd, Economic Geologist.

This is the title of a department bulletin now in press. It is an elementary discussion of the principles governing the selection of quarry sites, drilling, blasting, and crushing and screening.

The rapid expansion of highway construction in the United States has led to a demand for crushed stone which can not be met by commercial plants operating at fixed points, and the supply for which must come through portable plants operating at temporary quarries. Towns, cities, counties, and contractors are obliged more and more to resort to this practice, and there is a rapidly growing demand for information about the equipment necessary and the methods involved for the economical production of crushed stone on a small scale.

This bulletin has been prepared for the use of those unfamiliar with the important details involved. It treats of the factors which should be taken into consideration in selecting a quarry site, with reference to both the opening and operating the quarry itself, and the location of the crushing plant. The equipment necessary is listed and discussed, and in a chapter on "Operation" data are given on the operation of drills, the handling of explosives, blasting, and the opening of a quarry. The accurate keeping of costs is urged, and the cost data of a number of small quarries are given in the final chapter.

Results of Physical Tests of Road Building Rock in 1916 and 1917, Including all Compression Tests: By Prevost Hubbard and F. H. Jackson, jr.

In this department bulletin will be found the results of physical tests on some 655 samples of rock examined by the Office during the years 1916 and 1917. These tests were made for the purpose of determining the value of the materials for use in road construction. The bulletin is supplementary to United States Department of Agriculture Bulletin No. 370, which gives all the results of similar tests made in the laboratory of the Office since its inception in 1900 up to January 1, 1916. An interpretation of the results of these tests is also given in Bulletin No. 370. The results of the tests themselves are arranged by States, counties, and towns so as to make it possible for any one interested in the available road building rock of any particular locality to readily determine just what materials in the section have been examined by the Office. For the information of anyone interested in the utilization of stone as railroad ballast, the results of all compression tests have been included in the bulletin.

Gravel Roads: By Charles H. Moorefield, Senior Highway Engineer; Revision by Benjamin F. Heidel, Senior Highway Engineer.

Gravel suitable for road surfacing purposes occurs widely distributed and can frequently be obtained ready for such use more easily than fractured stone in other forms. It varies widely in the composition and size of the pebbles as well as in the character of the fine material mixed with it, In order to secure the best results it is necessary to adopt road construction methods to these variations. This Farmers' Bulletin discusses the properties of gravels as road surfacing material, their treatment, and the methods used in the construction and maintenance of gravel roads. It also deals with the design and location of roads.

Earth and Sand-Clay Roads: By Charles H. Moorefield, Senior Highway Engineer; Revision by Benjamin F. Heidel, Senior Highway Engineer.

Regarding the earth road as the first step to the construction of the higher types of road surfaces this Farmers' Bulletin discusses the considerations entering into road location and design so that all essential effort and expenditure shall be devoted to the production of a roadway suited to the immediate needs of light traffic and at the same time capable of being used as the basis for hard surfacing in the years to come. It also treats of the use of selected earths or "top soils," peculiarly adapted to the needs of light traffic and describes in detail the methods of mixing sands and clays to render them more stable under traffic.

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING ROAD PUBLICATIONS.

NOTE.—(Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free).

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

BULLETINS.

(In applying for these bulletins the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28").

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and Classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53").

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
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583. Report on Experimental Convict Road Camp, Fulton County, Ga.
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OFFICE OF PUBLIC ROADS CIRCULARS.

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OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
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63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETINS.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239".)

F. B. *239. The Corrosion of Fence Wire. 5c.
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338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c.
*461. The Use of Concrete on the Farm. 5c.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

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Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables upon the Penetration Test for asphalts and asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

*Department supply exhausted.

THE CITY'S PART IN FARM LABOR PROBLEM.

The problem of farm labor is largely a local one. It is necessary to meet the needs of farmers in large part by drawing upon near-by sources of labor. Most of the help needed on farms is of a skilled sort requiring previous farm experience. In towns and villages throughout the country from 30 to 40 per cent of the persons engaged in various lines of industries were born and brought up on farms. These men, therefore, by reason of their previous farm experience and their sympathetic understanding of agricultural conditions are best able to meet the farm-labor emergency wherever it may exist in farming communities.

The largest demands for farm labor are for short periods at seeding and harvest time. It is quite possible, therefore, for city employees to assist in this work without seriously neglecting city industries. Moreover, there are many unessential industries in all towns and villages which can be shut down temporarily during an emergency like the present in favor of the urgent demands for farm production. The Department of Agriculture is conducting an active campaign to bring about a closer business cooperation between the town and country. In this campaign city employers are requested to release some of their employees at certain periods for work on farms where their services may be urgently required. A canvass is being conducted in towns and cities in all States to secure the pledges of persons with previous farm experience who are willing to go out on farms for work during the coming season. The results of this campaign are very gratifying, but a much more active campaign must be pushed in many States where the residents of towns and cities have not yet realized the need of their cooperation in farm production and where farmers have not fully realized the importance of this source of farm labor. In Kansas, for example, the results thus far obtained indicate that 50,000 city and town residents with previous farm experience are willing to give from two to fifteen days of their time during their summer season to necessary farm work, especially harvesting. As another example of what can be done by an organization of city business men, attention may be called to a recent canvass by a committee of business men in Aberdeen, S. Dak. Within two days a pledge of 5,500 days labor on farms was obtained.

Some of the best and most alert farm laborers have been going to the city for years to engage in other lines of occupation. These men, when properly appealed to, are willing to go back to the farm temporarily in order to relieve the labor situation. The best method of making an appeal has been found to consist in the joint effort of a committee composed of a few farmers from the neighboring community and a few business men from the town or village who unite in the selection of one or two active business men in town to take a canvass of the business population and secure pledges from men who can render farm service during an emergency. In at least one State this canvass was taken in a very satisfactory manner by the pupils of the public schools.

In all States where the work is in progress the confidence of the whole community in their ability to meet the farm-labor situation is increasing, and this feeling of optimism rests upon the solid foundation of actual pledges of men who have had farm experience and who have lived near the farms on which their services may be required.

It is believed that the widest possible extension of this campaign of appeal to the business men and farmers for a close cooperation is the most logical method of meeting the farm-labor problem in a satisfactory way.

CLARENCE OUSLEY,
Assistant Secretary of Agriculture.

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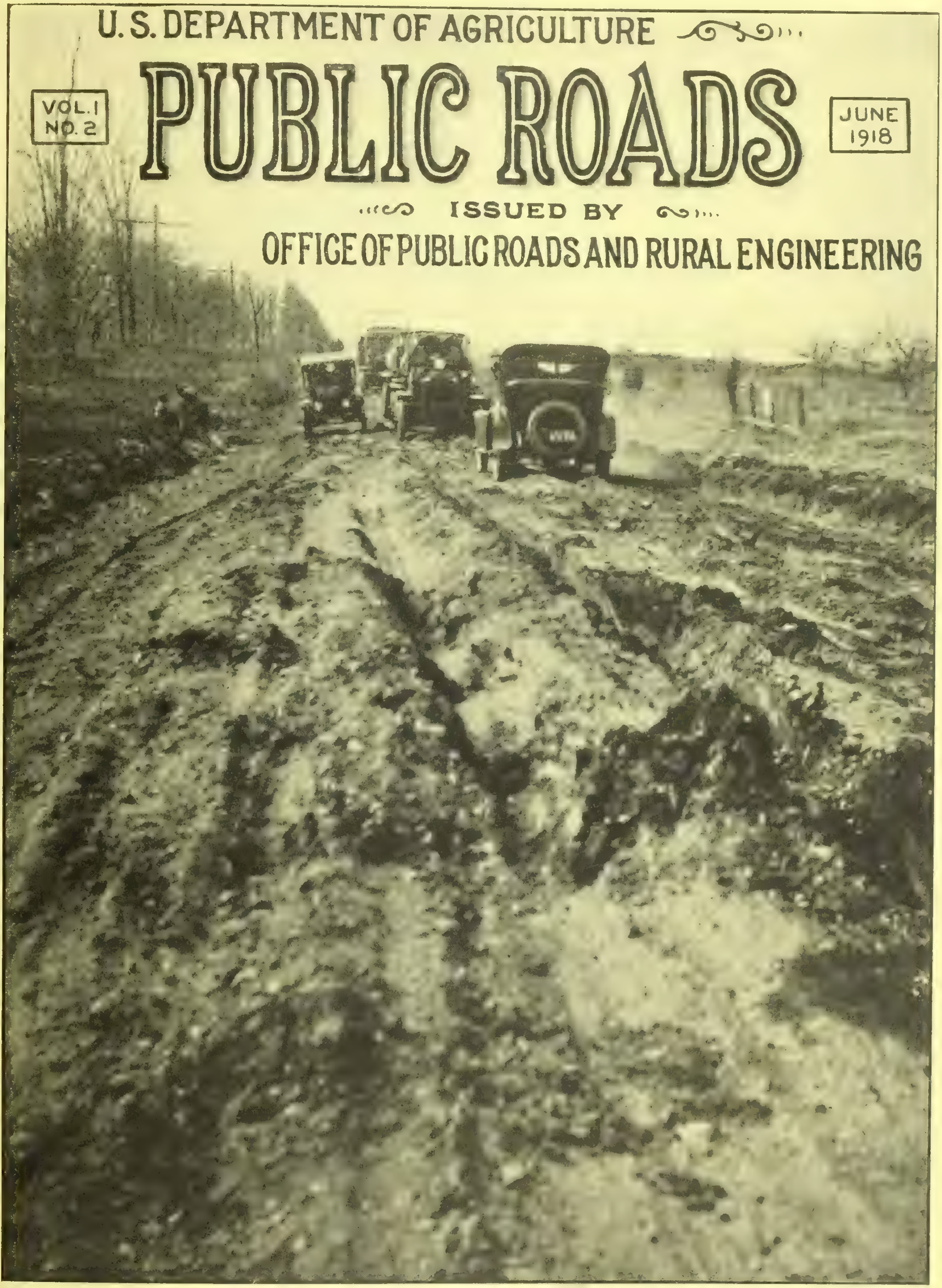

THIS PHOTOGRAPH WAS TAKEN NEAR CANANDAIGUA, N. Y., AND SHOWS WHAT AN EXCESS OF ABOUT THIRTY 7-TON UNITS ABOVE NORMAL TRAFFIC CAN DO TO A MODERN HARD-SURFACED HIGHWAY. ABOUT ONE AND A HALF MILES OF THIS ROAD IS IN LIKE CONDITION

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U. S. DEPARTMENT OF AGRICULTURE

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1918

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING.

Logan Waller Page . . . . Director.
P. St. J. Wilson . . . Chief Engineer.
J. E. Pennybacker . Chief of Management.
Jules L. Goldberg . . . . Editor.

THE U. S. HIGHWAYS COUNCIL

ALL functions of the various Government agencies so far as they relate to streets and highways hereafter will be coordinated in a body called the United States Highways Council, composed of one representative each from the War Department, the Department of Agriculture, the United States Railroad Administration, the War Industries Board, and the Fuel Administration. These representatives, under designation by the heads of their respective departments, held their first meeting June 8, and selected Logan Waller Page, Director of the Office of Public Roads, Department of Agriculture, as chairman, and J. E. Pennybacker, chief of management of that office, as secretary.

The council was formed primarily to prevent the interminable delays, financial loss, and the uncertainty incident to the method of taking up each highway problem in its turn with a separate and distinct Government agency. This council utilizes the efficient organizations of the 48 State highway departments with their trained personnel and their knowledge of local conditions as a medium through which the highway needs of the country may be brought to the attention of the Federal Government. It provides a single agency in the nature of a clearing house, where all highway projects calling for governmental action of any character, whether it be a question of finance, of materials, of transportation, or of war necessity or desirability, may be considered and appropriate action taken thereon.

The complexity of the highway problem can best be understood by a statement as to the manner in which each of these Government agencies is directly concerned:

The War Department constructs hundreds of miles of roads in cantonments and posts and is frequently interested in the highways connecting these cantonments and posts with cities and shipping points. It is also interested in the conditions of great through highways over which Government truck trains are transported. In short, any highway which affects any of the numerous war activities of the Nation is of interest to the War Department.

The Department of Agriculture, of which the Office of Public Roads is a part, has a most direct and far-reaching interest in highways, as the Secretary of Agriculture is intrusted with the administration of the Federal aid road act, which carries an appropriation of $85,000,000 during a five-year period, and calls for an expenditure of at least an equal amount by the State in conjunction with this Federal appropriation. The Office of Public Roads also expends a number of small appropriations under authority to make scientific investigations and to give out information concerning highways. In this educational work, as well as in the Federal aid highway work, it is in constant touch with the highway departments of the 48 States.

The Railroad Administration, controlling as it does all of the facilities of rail transportation, can influence vitally by its action the construction and upkeep of public highways, as vast quantities of crushed stone, gravel, sand, cement, brick, reinforcing and structural steel, and bituminous materials are required to be transported by rail. The acute shortage of open-topped car equipment on account of the needs for shipment of coal, coke, and ore renders it necessary that highway needs be met in a selective manner, so that really urgent work may be done and less important work be postponed. This situation has been met by the issuance of an order by the Car Service Section of the United States Railroad Administration (C. S., dated May 24), which order provides for appeal to the Director of the Office of Public Roads, through the State Highway Departments, where the needs are urgent and the local railroads can not handle the situation. The director in turn brings the appeal before the United States Highways Council for appropriate action.

The Fuel Administration, through its control of fuel, including fuel oils, finds it necessary in order to conserve the supply of fuel oil for the needs of our fleet, our allies, our merchant marine, and our munitions plants, to restrict the use of road oils, asphalts, and tars in street and highway work to really essential needs. In consequence, these materials for highway purposes are delivered by manufacturers and refiners only on a permit issued by the Fuel Administration based upon a recommendation by a committee representing the Office of Public Roads and the Oil Division of the Fuel Administration, this committee forming part of the United States Highways Council.

The War Industries Board, by reason of its control of many of the materials entering into highway construction and maintenance, including cement, crushed stone, gravel, sand, structural and reinforcing steel, and its power to establish priorities, allocate materials, and fix prices, enters very prominently into the field of highway work. Where questions falling within the province of the War Industries Board are brought before the council appropriate recommendation is made through the War Industries Board representative.

The Capital Issues Committee, while not represented in the council, still is interested in highway construction in that under the act approved April 5, 1918, it is required to pass upon bond issues involving $100,000 or more. As there are hundreds of millions of dollars annually voted and sold for highway and street purposes, it is evident that the Capital Issues Committee thus possesses a decisive influence upon the conduct of highway and street work.

The Highways Council has provided a definite form on which application to it for relief may be made and has placed a supply of these forms with the respective State Highway Departments. The council emphasizes the great need of conserving money, transportation, labor, and materials by restricting highway and street work to the most essential needs. It considers the maintenance of existing streets and highways logically should rank first in importance and that the reconstruction of those sections of improved highways and streets which have become too defective for maintenance should next receive attention. New construction is justified only where the highways are vitally important toward the winning of the war or for the movement of essential commodities.

OIL, ASPHALT AND TAR SUPPLY.

ONE of the many striking examples of the manner in which war necessities react upon the routine industrial life of the Nation is afforded by the order recently issued by the Fuel Administration restricting oils, asphalts, and tars for road purposes. The maintenance of the various forms of bituminous construction takes up a large percentage of the normal output of the oil refineries and of the plants producing coal and water-gas tars. Fuel oil has become an increasingly vital necessity for the operation of our fleet, and for the various war needs of ourselves and our allies.

Essential fuel oil requirements at this time necessitate withdrawals from the supply of such bituminous materials as would otherwise be converted into highway material. Hence, the order issued by M. L. Requa, the Chief of the Oil Division of the Fuel Administration, requiring that deliveries of bituminous road materials be made only on permit based upon the recommendations of a committee representing the Fuel Administration and the Department of Agriculture and coordinating with the United States Highways Council, of which Mr. Page, Director of the Office of Public Roads, is chairman.

The question has been asked repeatedly why asphalts and refined tars are classed as fuels. It is true that most of these products can not be used directly for fuel as can many of the fluid oils and tars. It is quite possible, however, to flux or cut back these semisolid or solid products with distillates so as to convert them into fuel oils. Moreover, it is recognized that the use of a considerable tonnage of the heavier products is of vital importance in maintaining roads absolutely essential to war needs. By limiting the use of present stocks of these products the supply of fuel oil is increased by the amount which would be required to replace the heavy products if they are used on roads which, under present war conditions, can not be classed as important. Owing to different and constantly changing production, storage and transportation conditions in various parts of the country, no hard and fast rules can be laid down as to the issuance of permits for the release of bituminous road materials and every application must therefore be considered in the light of its importance and the existing fuel conditions at that time.

The limitation in the bituminous materials for road and street purposes renders it absolutely necessary that the small available supply be so allocated as to take care of the needs of highway and street construction and maintenance in the relative order of their importance. Manifestly, the maintenance of streets and highways is as a general rule of primary importance, and in consequence, the committee carefully scans all applications with a view to giving preference to those which call for material for maintenance purposes, and these maintenance applications are in turn regrouped so that the most heavily traveled and most necessary highways shall receive first place in the approval of the committee. Dust prevention only and the treatment of earth roads with bituminous materials is considered as of least importance, and application for release of materials for these purposes should not ordinarily be made.

After the maintenance needs are met, the next class of highway improvement is the reconstruction of sections of important highway partially or wholly destroyed by traffic, and last will come new construction. In this latter class, preference is given to the filling up of short gaps in main highways and in meeting military needs.

For important work involving the use of large quantities of bituminous materials, permits are frequently granted for a supply which will cover immediate needs, usually for not over 30 days. If conditions warrant, a further release is made.

To the end that a simplified working plan should be put into operation and the most careful scrutiny given to all applications, it was provided in the instructions issued by the Fuel Administration that all the applications for highway work should be made on forms supplied by the Office of Public Roads and should be certified by the State highway department of the State in which the work is located, and the application then forwarded to the Director of the Office of Public Roads. The procedure is set forth clearly in the letter from the Director of the Oil Division of the Fuel Administration, as follows:

"In order that the fuel oil requirements of our Allies, as well as our own Army and Navy, and essential war industries may be fully satisfied, it is found necessary to limit the use of petroleum and coal in the manufacture of road projects, such as asphalt, road binders, road oils, tar binders or dressings.

"The United States is now being drawn upon to an ever increasing extent for petroleum products, especially fuel oil. It will be appreciated that this demand must be satisfied. Commencing this date we request that all highway work in your State of any character, including municipal work, involving the use of the above-mentioned materials, be passed upon by your State highway department. A special permit of the Fuel Administration, Oil Division, will be required before delivery of purchases will be authorized.

"Inclosed you will find forms on which all applications for the above-mentioned road materials must be made. Preference will be given to material for maintenance and repair work. The supply of the above material for road work is so limited that it is requested that all new construction involving these materials be deferred this year except in cases where such work is necessary toward the winning of the war. These forms should be filled out, covering maintenance, reconstruction or new construction, and certified to by the State highway department as to the vital necessity of the work under existing war conditions and the quantity of the material involved. They should then be mailed to Mr. L. W. Page, Director, Offices of Public Roads, Washington, D. C., Mr. Page acting as chairman of a committee which will consider the necessity of the material being supplied and make their recommendation to the Oil Division of the Fuel Administration, which will issue permits in accordance with the recommendation when the necessary material is available.

"It is requested that you give this matter full publicity, so that all parties concerned will be familiar with the procedure necessary to procure supply of these materials.

"Additional supply of inclosed forms can be procured on application to Mr. Page."

THE HIGHWAYS OF THE COUNTRY AND BURDEN THEY MUST CARRY.

APPARENTLY the point has been reached where the demands of traffic have exceeded the strength of the average road to meet them. Highways designed to withstand the pounding of ordinary loads, that have stood up under imposts they were intended to sustain, no longer appear to be adequate to meet the present-day conditions. Congestion on our railways, possibly more acute in some sections than in others, has put upon our roads a transportation burden never expected and consequently not provided for by the engineers who designed the highway systems of the States. Roads have been designed with the same care as given to other structures and with the same regard for the purposes for which they were constructed and the burdens they were called upon to bear. Widespread failure is demonstrative of the fact that roads can not carry unlimited loading. Their capacity is limited. If it is exceeded habitually and constantly, then they can not survive.

The products of our farms and of our factories must be moved. The wants of our urban dwellers must be met. But the needs of our country involved in this great conflict are paramount to the needs of single communities, and thus when avalanches of freight destined to fill the greater necessity made imperative the partial closing of our vast system of rail transportation to the smaller, the relief appeared to be in the motor truck and the highway. Single light units expanded into great fleets, then grew into heavier units that, in turn, developed into long trains. From horse-drawn vehicles with concentrated load of probably 3 tons at most, traveling at the rate of 4 miles an hour, sprung almost overnight the heavy motor truck with a concentrated load of from 8 to 12 tons, thundering along at a speed of 20 miles an hour. The result? The worn and broken threads that bind our communities together. The solution? That is the problem that confronts the men who will be called upon to meet the ever-growing demands upon our highways and to devise regulations fair to those who pay for their construction and to those who pay for their use. State highway officials have been asked to give their views. In the articles that follow they have discussed the problem.

New York Advocates Placing Reasonable Limit Upon Total Load of Motor Trucks.

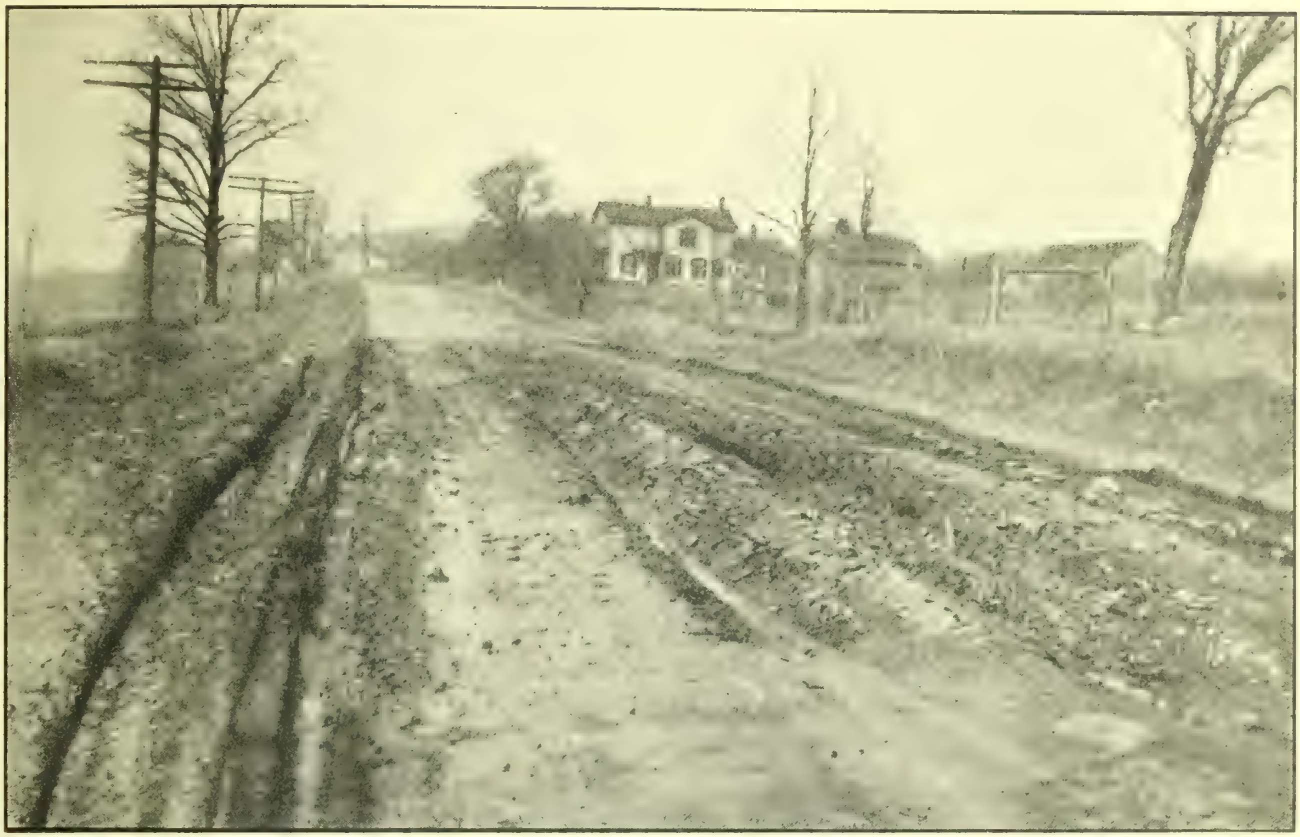
By EDWIN DUFFEY, Commissioner of Highways, New York.

IN common with other States called upon to bear a heavy and almost unforseen increase of traffic inlarge units, New York highways have suffered. No traffic in previous years has equaled the traffic in the critical period of this year.

As examples of what the highways have borne, three stretches of road can be presented. The first, section of water-bound macadam, oiled, constructed 10 years ago at an approximate cost of $10,000 per mile, between Victor and Mendon, has been broken, as shown, by the heavy traffic during the period of frost and the softening of the subgrade, which is of clay. The condition, as shown, prevails over several miles of this road and at present prices would cost about $20,000 per mile to repair. The second example is that of a bituminous macadam road taken about 2 miles east of Lima, Livingston County. This road was built in 1912 at a cost of about $11,000 per mile. During previous seasons this road stood up under all the traffic it was called upon to bear. This year, under probably thirty 7-ton units per day, it has reached its present condition. This extends for probably 14 miles, and it is estimated that it will cost $32,000 per mile to repair.

The third example is town macadam, water bound west of Canandaigua. This has been called upon to carry about thirty 7-ton trucks per day, with the result shown. (Cover.) About 200 feet are shown in this photograph, but altogether there is approximately about 1½ miles in similar condition. The probable cost of repair will be $32,000 per mile.

What can or should be done equitably to meet the unusual repair bills and insure highways capable of carrying the growing burdens is problematical. Prior to 1917 the only law providing for taxation or license of commercial motor vehicles was one that required an annual license fee of $5 per vehicle, regardless of size. In 1916 the legislature appointed a commission to inquire into the subject of license fees which should be paid by commercial and passenger-carrying motor vehicles. An extensive study was made by that commission, but its sole function was to determine in the end upon the fees which should be paid, and in my opinion (for I was a member of that commission) a schedule of fees was adopted and approved by the legislature which was very conservative as to the rates imposed.



MOVING VANS, PRODUCE, AND FREIGHT TRUCKS PUT THIS MACADAM ROAD BETWEEN VICTOR AND MENDON, N. Y., INTO THE CONDITION SHOWN. ESTIMATED COST OF REPAIR IS $20,000 PER MILE.

As far as taxation or license fees are concerned, it seems to me that such taxation or fees should be substantial, but not prohibitive. There is not likely to be much issue at any time over the fees to be charged for the lighter vehicles of either class. The important question will pertain to the heavy vehicles only. I do not see how it is practicable or advisable to attempt to assess to such vehicles their share of the cost of upkeep of highways, without reaching amounts that in effect will be prohibitive.

None of our old roads have been constructed for the extra heavy trucks with trailers. In many cases, especially under favorable conditions, we find our old roads successfully carrying trucks of the 4 and 5 ton capacity, even though it can be scientifically demonstrated that they are not built to do so. We must face the advent of the heavy motor truck. We must permit its use to the greatest weight possible, short of prohibitive injury or wear upon all the roads heretofore built. A reasonable limit upon the total load must be placed, however, and we must at the same time require a proper distribution thereof, or the rapid destruction of our old roads will be the result. We feel that there should be a limit, and if possible a limit that would remain unchanged for a number of years, so that our new roads might be designed to withstand the weights provided for, and our old roads reconstructed in like manner.

DEPENDS UPON LIMIT OF TOTAL LOAD.

There is a tendency on the part of highway engineers to say that the road of the future must be of the heaviest design and of a rigid type. However, if there can be a reasonable limit as to total load, it is quite possible that we can build of heavy design the bituminous type of road without concrete foundation. Such a road, if built, would require perfect drainage in our State, where heavy frost has to be contended with. The concrete type, as far as its carrying qualities are concerned, doubtless would answer the demand. The mixed type of bituminous pavement laid on a concrete foundation would also meet the traffic requirements. The concrete type, as near as a cost estimate can be made under the conditions now confronting the State, will cost for several years to come approximately $25,000 a mile. The bituminous mixed type with concrete base will cost several thousand dollars more. The bituminous type, penetration method, without concrete base but with a well-laid stone base 10 to 12 inches in depth, would cost at least $20,000 a mile. It is essential, if highway building is to proceed along scientific and rational lines, that highway engineers be furnished with the total maximum load and the kind of load which is to be provided for during the useful life of the road. Otherwise we may proceed to build a much heavier type of road than that now generally built throughout the land, and in a very few years find that the loads almost without notice have outrun the capacity of the roads.

On the other hand, without a limit on the total load and the distribution thereof there would result the destruction of a very large mileage of improved roads caused by a very few vehicles, and thus destroy the roads and defeat the very purpose sought to be attained by suspending rules as to limit. Surely the greatest amount of miscellaneous traffic should use the improved highways of the country at all times, and destruction by a few vehicles should be avoided. The roads must be preserved for the many and not destroyed by the few. I think this whole question has been much misunderstood in the popular mind. There is a belief that any restriction of excessive motor loads is selfish in its object and that at the present time these heavy vehicles are serving in a most useful and well-nigh indispensable way. As to the ordinary wear and tear that they cause, the subject may be considered as fairly open for discussion. But when the point is reached where destruction instead of wear is the result a wholly different question arises.

FEARS HEAVIER THAN 5-TON TRUCK.

In this state during the past four months a large number of United States Army trucks crossed our State from Buffalo to New York by way of Albany. The maximum truck that the Government sent to the seaboard is of the 5-ton capacity. The State undertook to provide for this service, regardless of the result. We have at the present time considerable information at hand as to the extent of the injury that has been caused. In some places destruction has been the result. This has been mainly confined to those sections where the oldest and most worn roads were encountered. The greater portion of this route, which is 450 miles long, has up to the present time withstood this heavy service—and that during the spring break-up. This has led us hastily to the belief that possibly we could provide for a truck of this capacity by making heavy appropriations for the repair of our old roads. It has in the same hasty way led us to the hope, at least, that if the Government motor truck were the heaviest vehicle that we had to provide for, our problem, financially and otherwise, would not get to a point beyond our control. If vehicles of greater weight, which would destroy, should be permitted to use all the improved highways of this State, now some 7,000 miles in extent, in such numbers as to bring destruction over a large mileage in a single year, the cost of meeting the situation would be burdensome beyond reason and the work of rebuilding would be so great in extent that it could not be done in the limited time which the public use of our highways would require. In addition to the 7,000 miles of improved highways throughout the State, it should be borne in mind in this connection, from the standpoint of this State, that the counties and townships have improved a mileage of over 10,000 miles, and these latter roads are of lighter type than any of those constructed by the State.

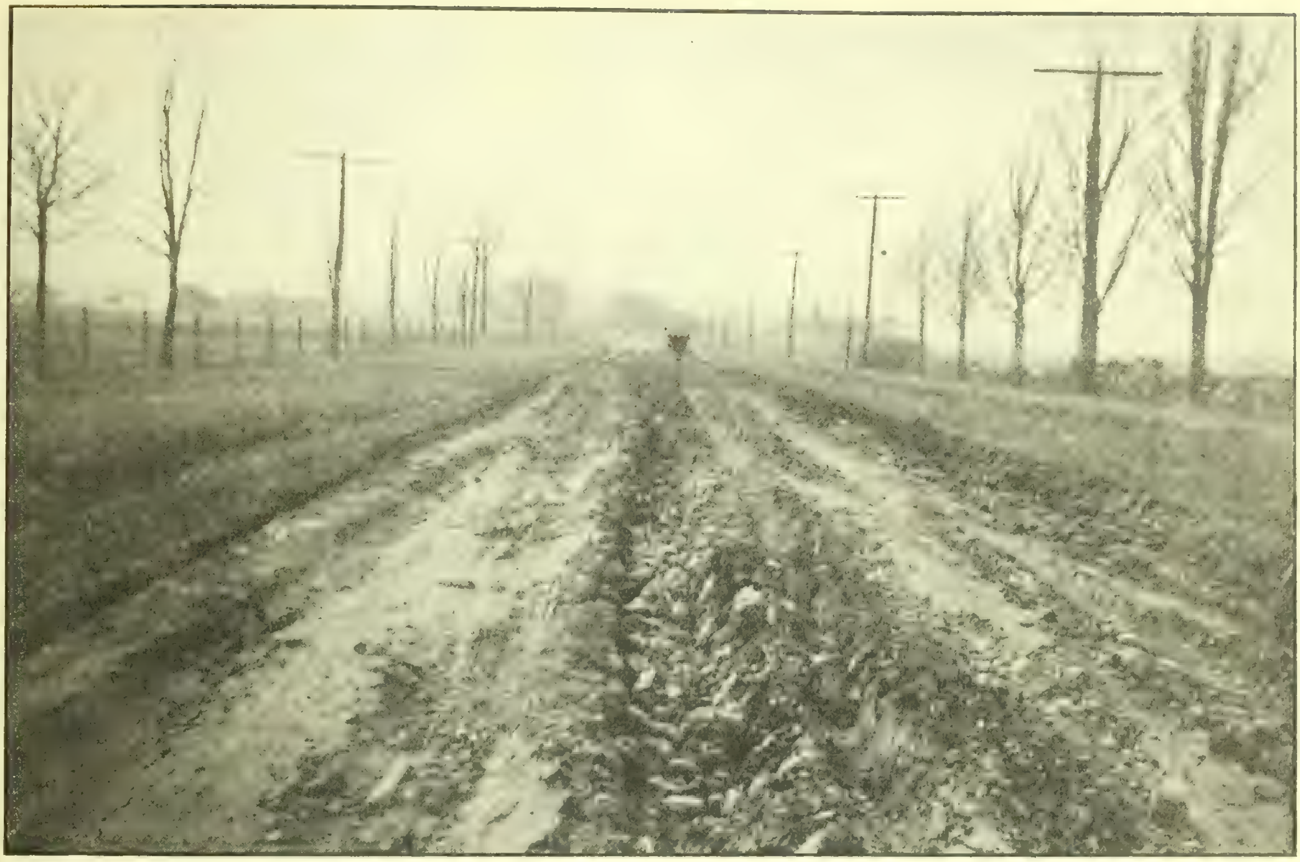
However, some trucks of much greater capacity than the Army motor truck—the number being very small—have here and there appeared upon our improved roads of the old type, and the damage they have caused has been very great. If we are right in this view, based upon the experience of a few weeks, namely, that in some way we can cope with the 5-ton truck and financially bear the burden, and as a result get a restriction as to load of trucks of this capacity, we shall have made much progress. Surely, if the heavy Government truck answers the requirements of our Nation in a time of war, it is fair to assume that it ought to be in maximum capacity adequate for peaceful pursuits.

WHAT REBUILDING WOULD MEAN.

Assuming in case there is no restriction that the number of motor trucks, say, in excess of the 5-ton truck and its load, will in a short time become large, there is much prospect of extensive destruction over the entire system above referred to. In a few years, without restriction, the number of these heavy trucks would be very great. Of course, some of them might reach such a weight as to break through the road at the outset and the amount of damage thus be limited because of the inability of such huge trucks to make progress over roads entirely unable to bear them. The scope of their activity would also undoubtedly be materially limited by the inability of the bridges to bear their loads. But between trucks of such abnormally large size and the truck of 5-ton capacity are undoubtedly many, whose number will constantly increase and whose weight will be such, if unrestricted, as will result in most serious damage.

The improved system in this state constructed up to the present time has cost in round numbers about $100,000,000, and the counties and towns have constructed roads, the cost of which is about $40,000,000. The extent of the financial loss can be estimated in a rough way only, but it is easy to see that, without restriction and with the great increase in the number of vehicles, the actual injury would amount to between one-quarter and one-third of the investment already made. A thing overlooked to some extent at least in a discussion of the matter is the fact that extensive rebuilding and reconstruction would mean for several years an interruption of traffic which would be most deplorable. The system now constructed in this State took nineteen years to build, and if we were to face a general rebuilding of the whole system within the next five to ten years, the maintenance of traffic during such building would be a very serious loss to the counties of the State.

It can not safely be said that the improved road systems now in use in this and many States can, from a scientific standpoint at least, carry loads



THIRTY 7-TON UNITS PER DAY BROKE UP THIS BITUMINOUS MACADAM ROAD IN LIVINGSTON COUNTY, N. Y. IT IS ESTIMATED THAT REPAIRS AT PRESENT PRICES WILL COST $32,000 PER MILE FOR PROBABLY 14 MILES.

greater than the 3-ton truck with load. Large expenditures in the way of strengthening and reconstruction must be made to meet the 5-ton-truck problem. We can not hope to restrict the use of the present improved highway system to those loads which highways engineers could properly say were the maximum the roads could stand, without serious injury and with ordinary maintenance and repair. Again I say that while we expect that we must provide for something greater than this, we must know the maximum load we are to face before either the engineering or the financial question can be met in any sane way.

MANY THINK 3-TON TRUCK BIG ENOUGH.

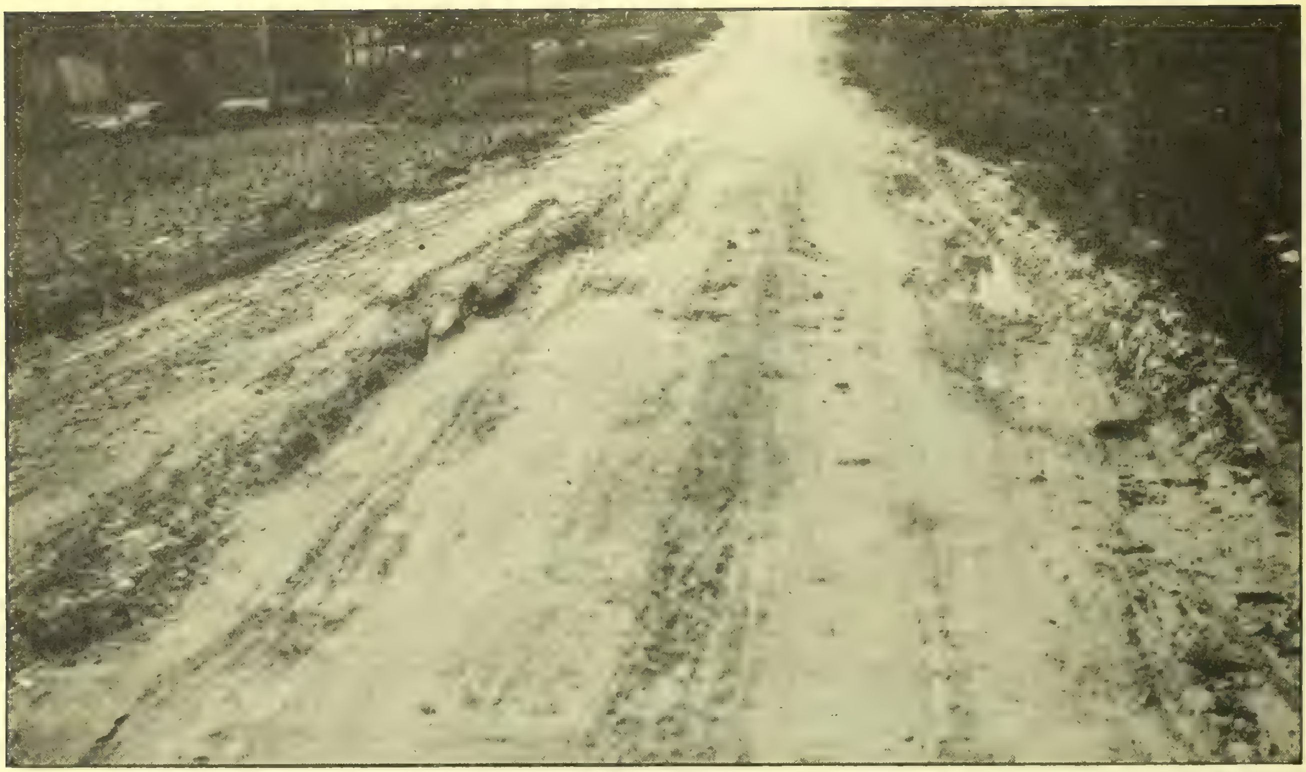
It is the belief of many that the 3-ton truck answers nearly all of the present day requirements. After recent conferences with persons representing truck manufacturers I found that there was quite a general opinion that the 5-ton truck might well be considered the maximum. If the 3-ton truck, or possibly the 4-ton truck, were to be the maximum truck in use, the problem from the standpoint of the highway engineer would be to a large extent solved. We feel that in some way and without revolutionary conditions such a vehicle could be provided for, and all the highways kept continuously open to public use.

In the State of New York during the year 1917, 55,401 motor trucks were licensed, of which 23,462 were registered for use outside of New York City; of this latter number, trucks having a capacity of five tons or over comprised only 6½ per cent, as will be seen from the following tabulation:

Capacity of truck.	Registered in New York City.	Registered for use outside of New York City.
2 tons	15,817	16,517
3 tons	3,963	2,881
4 tons	2,707	1,408
5 tons	2,102	1,081
6 tons	1,610	488
7 tons	1,004	280
8 tons	1,104	292
9 tons	683	115
10 tons	1,261	264
11 tons	953	86
12 tons	455	10
13 tons	116	3
14 tons	79	5
Over 14 tons	85	2
Total	31,939	[1] 23,462

[1] These include trucks used in the cities of Buffalo, Rochester, Syracuse, Utica, and Albany, as well as in 50 other smaller cities.

The whole problem is being considered by this State from the standpoint of the rural improved highway. What shall be used within city limits, where adequate pavements are provided, is another question, and probably should be determined from the standpoint of the city only, and kept wholly separate from the problem as to the rural improved highways.



ON THE BELAIR ROAD AT CHURCHVILLE, MD. THIS ROAD, 14 FEET WIDE, 6 INCHES THICK, MACADAM, CLAY SUBGRADE, WAS CONSTRUCTED IN 1913 AT A COST OF $12,000 A MILE. IT IS WELL DRAINED AND WAS IN GOOD CONDITION PRIOR TO THE SPRING OF THIS YEAR, WHEN THIS PHOTOGRAPH WAS TAKEN.

Abnormal Traffic Causes Maryland To Ask $500 Fee for Heaviest Trucks

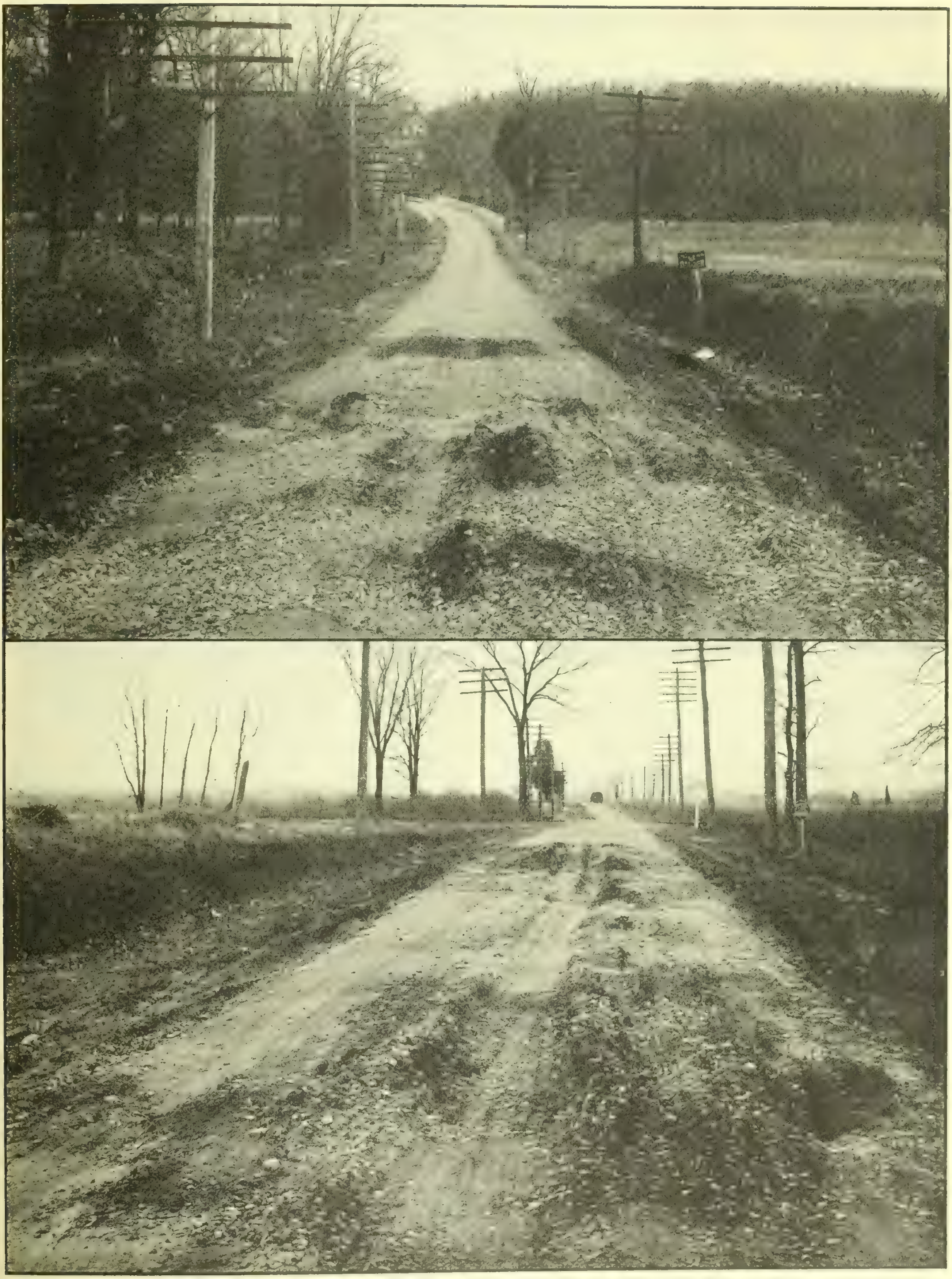
By J. N. MACKALL, Chief Engineer, Maryland

THE matter now commanding the attention of the highway officials in almost every State is that of keeping their present roads in repair for the duration of the war under conditions which are abnormal in every way. This is especially true in the State of Maryland.

The road system of Maryland has been constructed during the last 10 years, during all of which time the roads have been built of a higher character from year to year to take care of the almost daily increase in kind and character of traffic. The original roads constructed in Maryland were principally of water-bound macadam, with a width of 12 feet and a thickness of 6 inches. Later the depth was increased to 8 inches and the width to 14 feet, and still later to 16 feet. Within the last few years the roads have been built principally of concrete 14 feet to 16 feet in width, with an average thickness of 6 inches. These roads stood up well with normal maintenance under the traffic which they were called upon to bear. In the spring of 1918, however, the roads began to be subjected to a traffic which it was never intended they should bear, and under which they were unable to stand.

In addition to the abnormal movement of motor trucks over these highways, the weather conditions during the spring of 1918 were probably the worst in many years. The snow and frost during the winter were unusually deep, and a complete thaw came immediately after this frozen condition, rendering the shoulders and subgrades very soft. The abnormal motor-truck movement over these highways has been caused by three conditions, first, the movement of materials to the proving grounds and contonments; second, the tie-up of the railroads required that a great deal of private hauling be done over these roads by motor truck; and third, by the transportation to tidewater of a large number of motor trucks intended for service in France. These motor trucks came loaded with parts, which made the total load in the neighborhood of 10 tons.

Say! Have You Done Your Share? Well, Do More. Go Over the Top. Save and Keep on Saving W. S. S.



VIEWS OF TWO SECTIONS OF THE WASHINGTON-BALTIMORE BOULEVARD IN THE VICINITY OF SAVAGE, MD. THEY WERE CONSTRUCTED IN 1912, COST $12,000 A MILE, ARE OF MACADAM ON A CLAY SUBGRADE, 14 FEET WIDE, 8 INCHES THICK, WITH 5-FOOT SHOULDERS, AND WELL DRAINED. THEY STOOD UP WITH ORDINARY MAINTENANCE UNTIL THIS SPRING.

SEES MAXIMUM IN 10 TONS.

It is well established that the roads shall be preserved for the greatest good to the traveling public, and this presents the question of extraordinarily large trucks and heavy loads. Is the policy of the highway departments going to be one of permitting manufacturers to send over their roads any kind of truck load which they propose to design, or is there going to be a tendency to try to keep these trucks to a size which the roads of the country can stand? It seems to the writer that it is absolutely imperative for the proper care, preservation, and maintenance of the existing roads that the size of motor truck and kind and width of tires shall be controlled to such size as the roads can stand. Just what this size is at this time the writer is not prepared to say, but he does believe that certainly a maximum of 10 tons for a loaded truck is all that should be permitted and probably this will have to be reduced.

It is hardly reasonable to expect that a very few individuals who profit by the use of large heavy trucks should be permitted to destroy the roads which would ordinarily be used by an infinitely greater number of truck and pleasure vehicle owners who desire and have a right to use these roads. It is also well established that the persons who derive the benefit from the road should be the ones to stand the expense of maintenance, and equity would dictate that the charge be directly in proportion to the damage done.

The roads have in most cases originally been built from the general fund of the State, and the general fund should not be called on to pay the expense of maintenance. It would seem, therefore, that the pleasure vehicle and motor truck should pay probably a large portion, if not the entire part, of this maintenance. The pleasure-vehicle owner in the past has gladly and willingly paid his proportion, but the truck owner has in a large measure escaped his share of the burden.

ACTUAL TRIAL TO DETERMINE FEES.

The Maryland Legislature at the 1918 session passed a bill prescribing motor license fees as follows:

Pleasure vehicles, per horsepower	$0. 60
1-ton motor truck	20. 00
2-ton motor truck	40. 00
3-ton motor truck	60. 00
4-ton motor truck	100. 00
5-ton motor truck	150. 00
6-ton motor truck	300. 00
7-ton motor truck	500. 00

It will be seen from this that the license for large trucks is heavy. Whether or not it is too heavy or heavy enough can be determined only by actual trial.

In Maryland the boulevard between Washington and Baltimore and the road via Belair and Havre de Grace to the Delaware line has failed in a number of places on account of the continued heavy traffic and will require complete rebuilding. To do this and at the same time widen the boulevard, the State plans to expend $350,000.

It would seem that we are justified in drawing the following conclusions from our experience in this State during the past winter and spring:

First. That the size of motor truck should be regulated to such size as improved roads built in the best manner which local conditions will permit, are able to withstand.

Second. That the cost of maintaining these roads should be paid by the traffic using them in as near as possible a proportion to the damage which they do.

Massachusetts Sees the Solution in Limit Upon Capacity and Loads of Trucks.

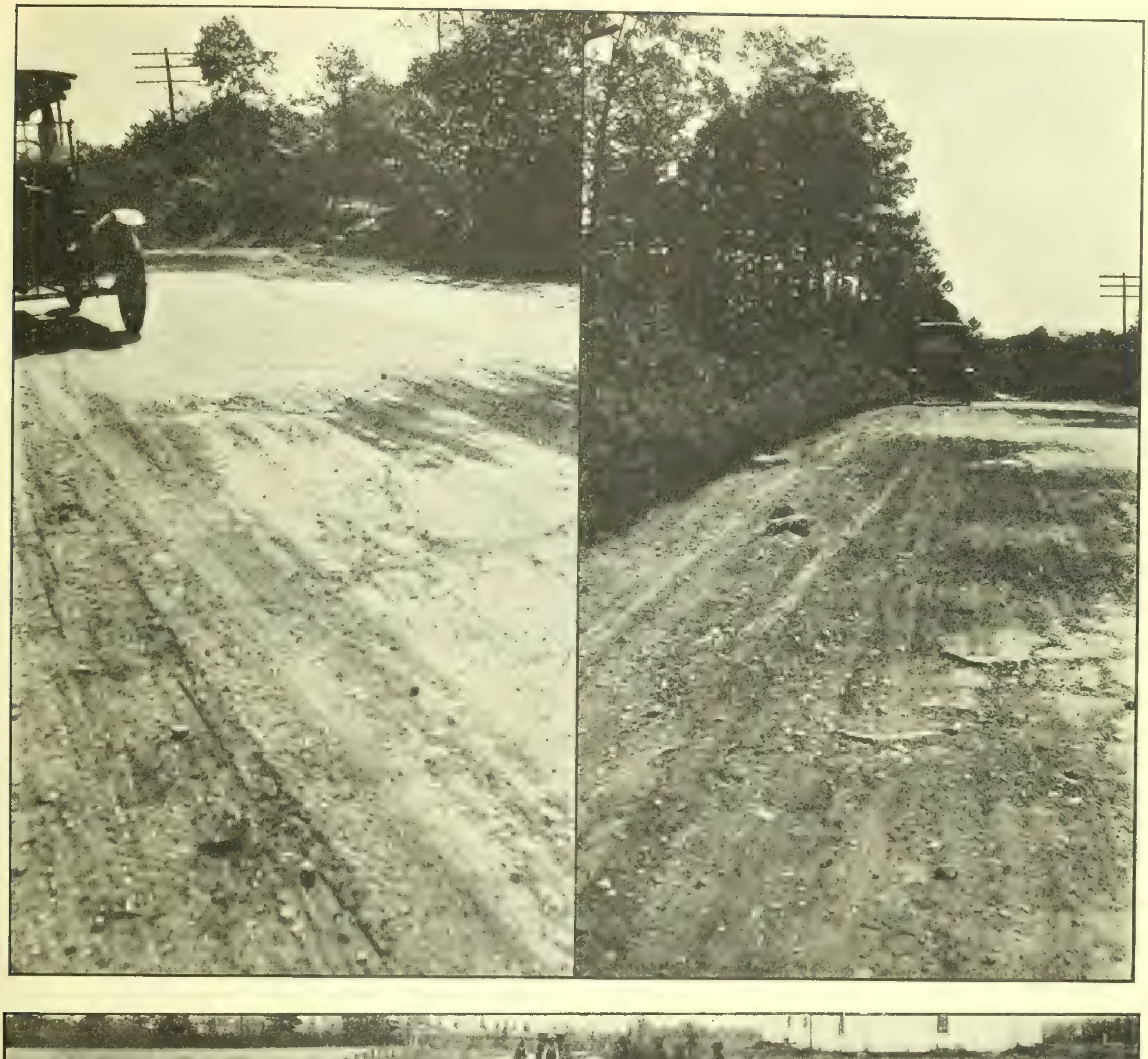
By WILLIAM D. SOHIER, Chairman Highway Commission.

THE road situation in Massachusetts might be summed up as follows:

There are some 1,200 miles of State highway and 800 miles on the same main through routes which have been built under the supervision of the State, but where part of the money was furnished by the counties and municipalities. Besides this there are probably five or six hundred miles more highway on main routes that have been built and are cared for by the towns.

The tremendous increase in motor-vehicle traffic since such vehicles became so numerous has made necessary a very large expenditure, the amount increasing each year, to even reasonably maintain these roads in passable condition. Ten years ago the amount available for the maintenance of State highways was about $100 a mile a year. At that time our engineers estimated that something over $300,000 was necessary in addition, to resurface certain worn-out sections of main road. Two years after this, when the motor vehicles continued to increase, we were actually spending over $300 a mile a year for the maintenance and resurfacing.

The motor-vehicle fees were made available for the maintenance of State highways, but the traffic has increased so fast, especially the truck traffic on the main roads, that while we have nearly $2,000,000 available, it was not nearly sufficient



AT TOP—FAILED SECTIONS ON CONCRETE ROAD BETWEEN ABERDEEN AND ELKTON, MD. AT BOTTOM—THE WASHINGTON-BALTIMORE BOULEVARD AT MUIRKIRK, MD., COST $15,000 A MILE TO BUILD IN 1913. IT IS 14-FOOT MACADAM, 8 INCHES THICK, CLAY SUBGRADE, 5-FOOT SHOULDERS, AND WELL DRAINED. LIKE OTHER ROADS, IT WAS IN GOOD CONDITION UNTIL THIS SPRING.

WATER-BOUND MACADAM, OIL SURFACE TREATMENT, AT WAYLAND, MASS. SURFACING 6 INCHES, BLANKET COAT 90 PER CENT HOT OIL ONE-HALF GALLON PER SQUARE YARD IN 1910, ONE-HALF GALLON HOT TAR PER SQUARE YARD 1909. REBUILT IN 1916, BERMUDEZ ASPHALT PENETRATION, 5 INCHES BROKEN STONE BASE OVER 12 INCH GRAVEL FOUNDATION, WITH 2 1-2 INCH BERMUDEZ ASPHALT TOP.

to resurface and strengthen the various old and weak links in the main routes where some 800 miles of water bound macadam or gravel roads were being rapidly destroyed by this heavy traffic.

Last year the commission spent over $2,000,000 in this maintenance work on State highways alone, and spent about $1,250,000 resurfacing and strengthening about 85 miles of road on main lines and widening 26 more miles.

The average cost for putting on a bituminous surface and patching the road was nearly $500 a mile on the old roads, and this was outside of the resurfacing.

REPAIR COST MAY BE DOUBLED.

To maintain our roads this year will require an expenditure of from 50 to 100 per cent more money for the ordinary maintenance, patching, and bituminous surface treatments on the older roads, because of the increased cost of materials and labor. An average of 100 per cent is a low figure if our main through routes in the country districts are going to be used for long-distance traffic with heavy trucks.

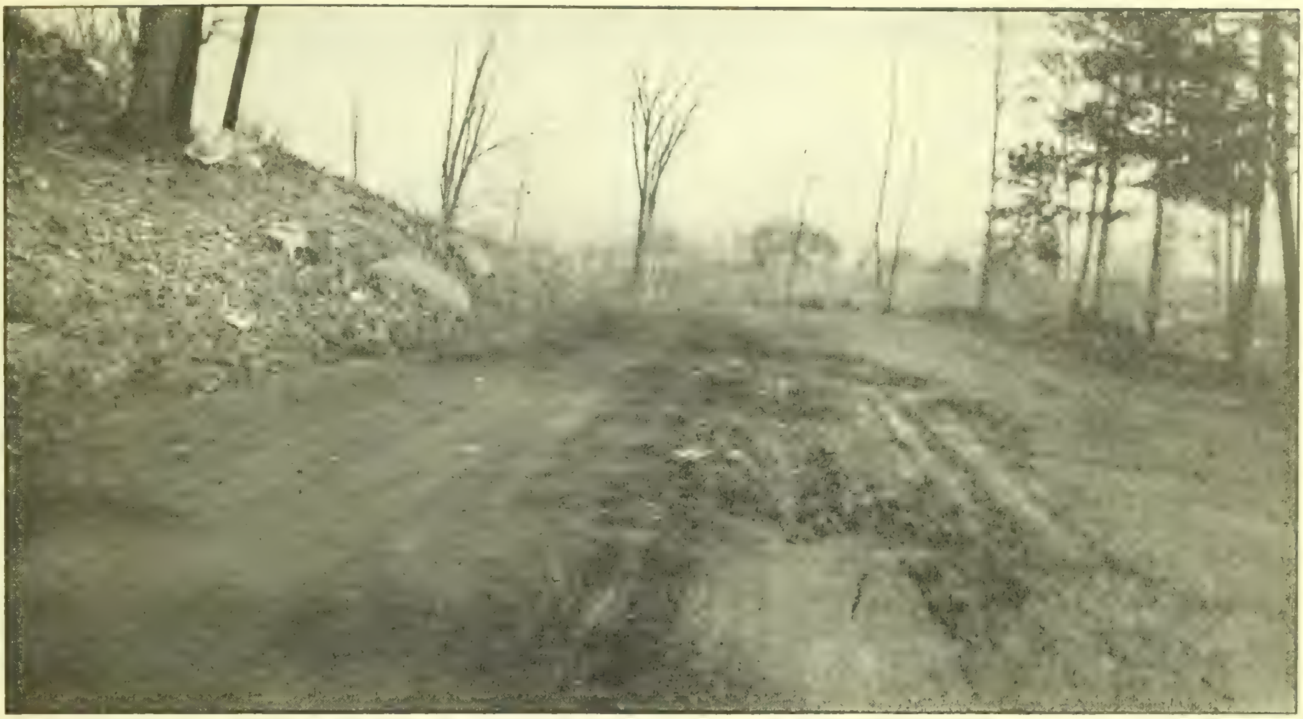
Out of the 1,200 miles of State highway alone in this State, something like 600 miles are 10 years old and have not been strengthened or resurfaced. They are old water bound macadam or gravel roads, the hardened surface being 15 feet and the shoulders 3 feet. They all need resurfacing and widening to at least 18 feet with 3-foot shoulders; but under present conditions this can not be done for less than $20,000 a mile, even if we can secure the necessary bituminous materials.

If heavy trucks carrying loads are used in large numbers, over 2,500 miles of improved water bound macadam and gravel roads in this Commonwealth will be very much injured and quite rapidly destroyed unless very large amounts are spent on them in constantly maintaining them. This can not be done unless the necessary bituminous materials can be secured, because with our main roads having from 500 to 1,000 motor vehicles a day—and it seems likely that they are going to be used by over 100 trucks a day, which is entirely new traffic out in the country—they will certainly go to pieces in a few months and become practically, if not entirely, impassable.

The crops along the sides of the roads, especially the hay crop, for a long distance would be destroyed by the road materials blowing over them. In actual experience we have found during the last eight years that the money was absolutely thrown away on any main highway that we built, if it were water bound macadam or gravel and we could not prevent its being destroyed by the use of some bitumen. A week or two of this heavy truck traffic would disintegrate any water bound macadam we have.

If we are obliged to allow these roads to deteriorate because of this traffic, all the sections which are

A Dollar in the Pocket is a German Dollar, a Dollar Spent Unwisely is a Traitor Dollar, But a Dollar Invested in United States Government Bonds is an American Dollar. W. S. S.



NEAR SUDBURY, MASS. WATER-BOUND MACADAM 6 INCHES THICK. BLANKET COAT ONE-HALF GALLON OF 90 PER CENT OIL IN 1910 AND 1911; ONE-HALF GALLON TAR IN 1909. ROAD BROKEN UP UNDER TRAFFIC, REPAIRED WITH ROAD SCRAPER BEFORE PHOTOGRAPH WAS TAKEN.

not built in a permanent modern way will certainly be destroyed in a few months. It would be a low estimate to say that it would cost from $40,000,000 to $60,000,000 next year to replace them with any type of road that could be built to stand this traffic, whether of concrete or otherwise. Meantime the traffic would be congested and the highways could not be used by the through traffic, because, certainly in wet weather, they would be impassable and at all other times they would be almost impassable because of the holes and ruts that would develop in a month or two.

PLANNED TO USE LOCAL MATERIALS.

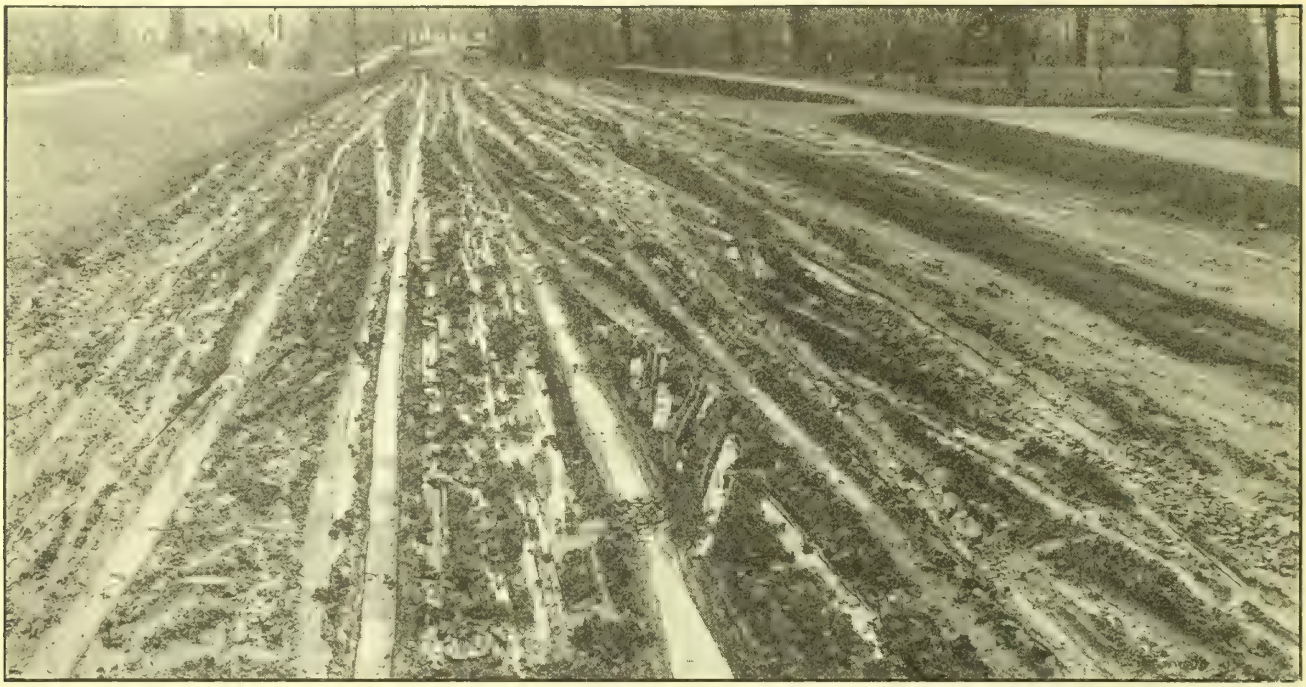
We had planned that all of our work this year, whether our own or in combination with the towns, should be confined to the main through routes of great importance, say not more than 10 per cent of the roads in this State. We had also planned to use local material and save car shipments, even when the local materials were of inferior quality but could be used if proper bitumen could be secured. A softer stone or poorer gravel can be used in combination with bitumen. While the roads would not wear as long, we felt that in these times as this work could be done without closing them so they could still be used by the traffic, and as four carloads of bitumen would be sufficient to construct a mile of road which would require 40 carloads of cement or from 70 to 80 carloads of imported stone or gravel, that this would save rail shipments and thereby help the general traffic situation.

We are receiving to-day substantially $2,000,000 from the motor vehicle fees. Without this money not only our roads but a great many miles of town roads that we use these fees on would be destroyed.

The trucks are not now paying their fair share, as our fee is only $5 for the first ton and $3 for each additional ton. In my opinion a much higher fee is necessary unless the Government is going to put very large sums of money into the roads. The States and municipalities could not in these times afford to increase their road appropriation very largely.

England's experience, as well as ours, has shown conclusively that the cost of maintaining a water-bound macadam road, even when the surface had a bituminous treatment, has always been a half a cent a ton a mile, and quite often it has been a cent and a half a ton a mile, and these tables included all classes of vehicles, pneumatic tires as well as trucks. Undoubtedly the cost of repairing the damage done to a road by trucks alone would be vastly greater than that done by the small cars, and would amount to more than one and a half cents a ton a mile. One can readily see that the 1-ton truck which makes 60 miles a day costs for the upkeep of the road 60 cents a day, and for 300 days a year it would be $180 a year. A 5-ton truck damages probably five times as much, or even more, as many roads which would carry a 1-ton truck reasonably well have not a strong enough foundation to carry the 5-ton truck.

A Country Worth Fighting For is a Country Worth Saving For. W. S. S.



SECTION OF THE LENOX, MASS. STATE HIGHWAY. TRAP 15 FEET BY 6 INCHES BY 4 INCHES. RESURFACED WITH TRAP, 10 TONS TO 100 FEET IN 1908. PATCHED IN 1911 STANDARD A ONE-HALF GALLON PER SQUARE YARD, ONE-FOURTH GALLON PER SQUARE YARD LIGHT OIL IN 1914 AND ONE-FIFTH GALLON IN 1916.

URGES USE OF LIGHTER TRUCKS.

Of course it is realized by all road builders, and it should be by the general public, that the country roads built of water-bound macadam or gravel can not withstand city traffic which requires granite block or other pavement, usually upon a concrete base to stand up. Consequently heavy motor trucks will rapidly destroy these country roads that were built for entirely other uses. The rebuilding of them to withstand the tremendously heavy motor truck traffic would be an enormous task and would cost much more than my estimate of $60,000,000 for 2,000 miles of road in this State.

Consequently I hope they will not concentrate too much heavy traffic on these main lines. I would suggest that smaller trucks be used, with lighter loads, 2 or 2½ tons in place of 5 or 6 tons, because with heavier vehicles it would not take a great many of them, in my opinion, to destroy the road, because it has not been built with a sufficiently strong foundation or of sufficiently strong materials to maintain this traffic, and this without any regard to the amount of money that might be available for maintenance.

We should soon be in the condition that the roads are back of the French Army, where they have a man every few feet back of the fighting line constantly spreading material on the road and letting the traffic roll it in, and even at that in wet weather the mud is ankle deep.

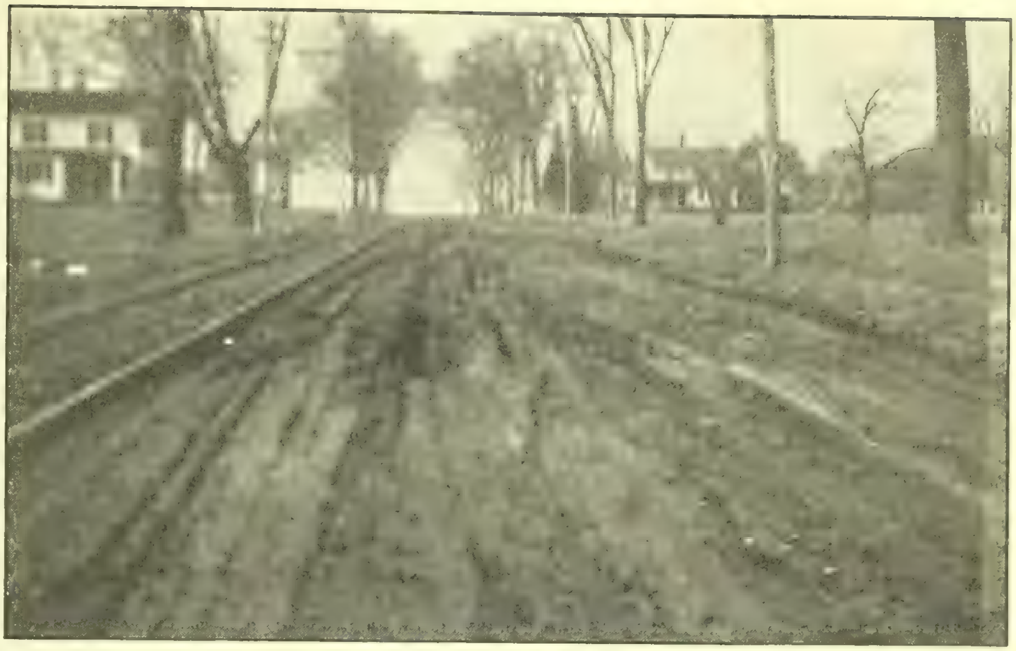
An army officer in charge of the roads back of a single British regiment, Maj. Mackendrick, wrote that he had used as much as 2,000 tons of crushed stone in one day in his division, and had 10,000 to 12,000 men at work.

Connecticut Restricts Loads on Roads But Plans to Strengthen its System

By C. J. BENNETT, Highway Commissioner.

THE State of Connecticut, through its highway department, is faced, as are all other States, with the problem of taking care of motor trucks of increased weights. More damage is done by this heavy traffic in the spring, when the frost is coming out of the ground, than at any other season.

Vivid examples of the tremendous increase in traffic and its result are illustrated in two roads, photographs of which are presented herewith. The first, on the Berlin turnpike between Hartford and Meriden, a half mile of which is broken as shown. This road was built of water-bound macadam, cold-oil treated in 1912, has a 7-inch trap rock surfacing with a clay subgrade. The adequacy of the drainage probably is questionable. In 1915 there was practically no heavy truck traffic over this highway.

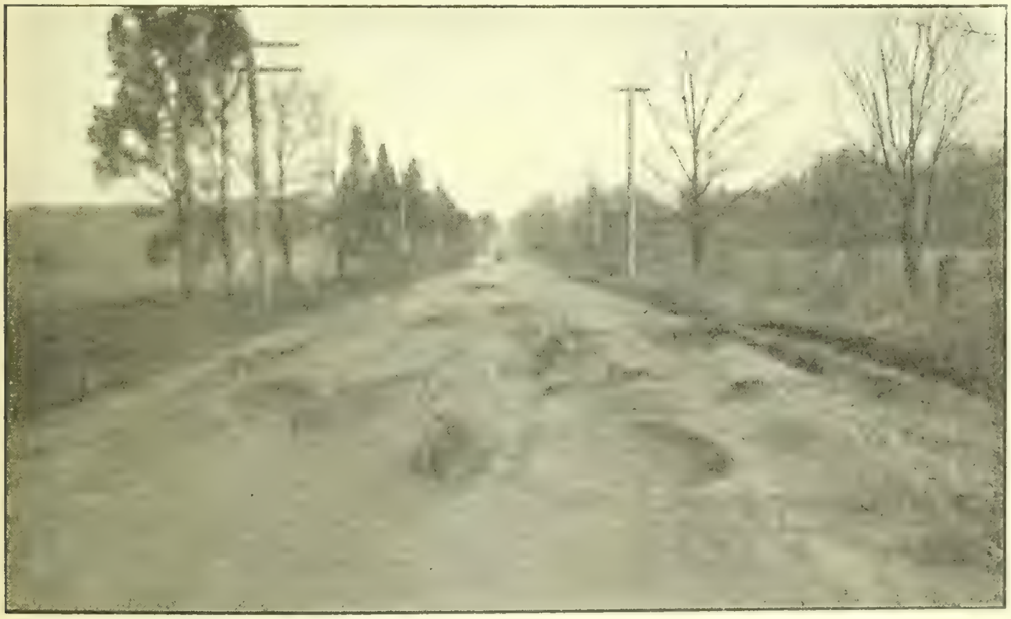


ON THE BERLIN TURNPIKE, BETWEEN HARTFORD AND MERIDEN, CONN. THIS ROAD HAS BEEN CALLED UPON TO CARRY 200 5-TON TRUCKS PER DAY. THE RESULT IS SHOWN.

In the present emergency there are probably 3,000 vehicles per day, of which 200 are 5-ton trucks. The other example is an earth road with crushed stone top, built in 1913, on the Waterbury-Southington highway. This road is surfaced with 3 inches of trap rock on a clay base and subgrade. Three-fourths of a mile of it is now broken as shown in the illustration. In 1915 the heavy traffic units going over this road did not exceed 50, now out of a maximum of 2,500 vehicles about 250 are of the heavy truck type.

The State roads, when originally built, were not built to carry the excessive truck loads which are now passing over them, and the weakness of these roads develops particularly during the bad subsoil conditions when the frost is coming out of the ground.

There are two remedies for this ill: First, the restriction of weights of trucks and the stopping of truck traffic when the damage is greatest; and, second, the construction of roads sufficiently strong to carry reasonable loads.



THIS HIGHWAY, BETWEEN WATERBURY AND SOUTHINGTON, CONN., BEARS A DAILY TRAFFIC OF 2,500 VEHICLES, OF WHICH ABOUT 250 ARE HEAVY UNITS

It is, of course, impractical to prohibit the use of roads by trucks, even for a short time, however great the damage, and it is also manifestly impossible to construct the roads sufficiently strong to carry any load which may pass over them. Consequently, a compromise must be reached, and this compromise in Connecticut, at least, has taken the following course:

Loads on four wheels are restricted to 25,000 pounds, except that in special instances which may be designated by the highway commissioner, heavier loads are allowed. License fees are out of proportion, as truck weights increase, which tends to discourage the purchase of extremely heavy truck units and to provide for the purchase of additional trucks or the use of rubber-tired trailers. The effect of these regulations is to limit the truck capacity to that of a 5-ton truck with a reasonable overload.

On the other hand, the State Highway Department has been working along definite lines, looking toward the strengthening of its road system so that little, if any, damage will be done to the roads, providing the above restrictions are followed.

A system of pavements has been designed and is being constructed, in order to allow of the use of motor trucks within reasonable limits. These pavements must have a strong foundation, preferably of Portland cement concrete, and be so designed as to stand the wear and tear on the surface, so that gradually the State highways through the rural sections are becoming of the same character as city pavements.

With the above policy it would appear that eventually a compromised solution of the difficulty would be reached. If all restrictions as to weights of vehicles were removed, the result would be the breaking down of many long sections of highway which have not already been strengthened, and result in the entire stagnation of traffic at certain periods in the year, which must not be allowed. Certainly a 5-ton truck with trailers distributing the load over the surface of the road, rather than centering an extremely heavy load on four wheels, would solve the difficulty.

Solution of the Growing Problem May Be Found in Cooperative Action.

By CHARLES M. UPHAM, State Highway Engineer, Delaware.

WHEN pleasure autos were first introduced the percentage of improved roads was very small; the roads that were improved were generally radiating from business centers, and there were very few improved trunk-line highways. At that time macadam was the universal improved highway pavements. The autos quickly demanded that not only should the mileage of improved roads be increased, but the type of pavement should be changed to something more substantial than the water-bound macadam. Both of these demands have been answered and the mileage of improved roads have been increased and types of pavements have been produced, at moderate cost, that could withstand the passenger auto and light truck traffic.

For a time the new roads stood up under the traffic and certain localities enjoyed good roads; with moderate maintenance the old roads were kept up, and for reasonable cost new roads that could withstand the ordinary traffic had been constructed.

A few medium heavy auto trucks were produced and operated in or near large cities. The city pavements were constructed on good foundations, and no great damage to the pavement was noticed.

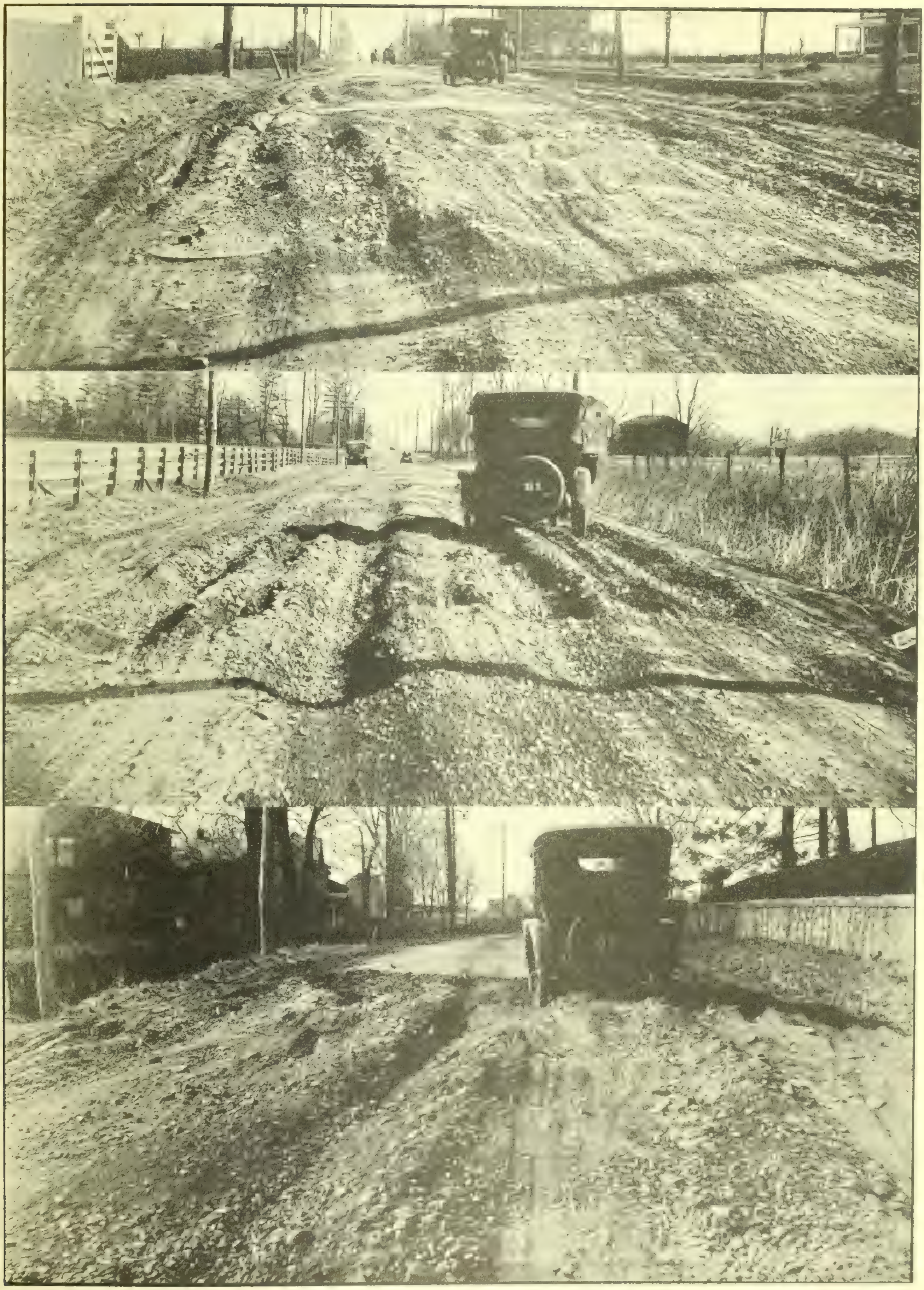
The trucks in themselves were a great success. Without any thought or regard of the highways the capacity of the trucks were further increased and their number grew rapidly. They were operated not only in the cities, but in every part of the country, and their effect on the roads was soon felt. It was found that on many of the roads which had been standing up under the ordinary traffic with moderate maintenance the new upkeep was doubled and trebled, and in many cases it was necessary to reconstruct the pavement. The passenger auto demanded that the roads be improved; the trucks are now demanding not only improved roads, but pavements of tremendous strength. This means that thousands of miles of the present roads are not strong enough to withstand the heavy auto trucks, and a large part of the vast amount invested in roads to-day will be lost unless conditions are modified.

There are many roads now being damaged and broken up by auto trucks on which the bonds that paid for their construction have not been retired. The auto truck has made it necessary that a stronger pavement be constructed on these roads, and now, because the traffic demands have surpassed the strength of the road, a new and stronger pavement must be constructed before the expected life of the old one has expired, and thus two roads must be built and paid for while the benefit from only one will be realized.

WOULD LIMIT LOAD ON SINGLE TRUCK.

Just at the present time among the heavy trucks the 5-ton truck is the most numerous. If all pavements were brought up to the strength of withstanding the demands of these 5-ton trucks, what assurance is there that the truck capacities will not be increased after the roads are brought up to the 5-ton standard, and that our roads will not be torn to pieces by still greater trucks? It seems that in order to prevent great economic loss the loads on

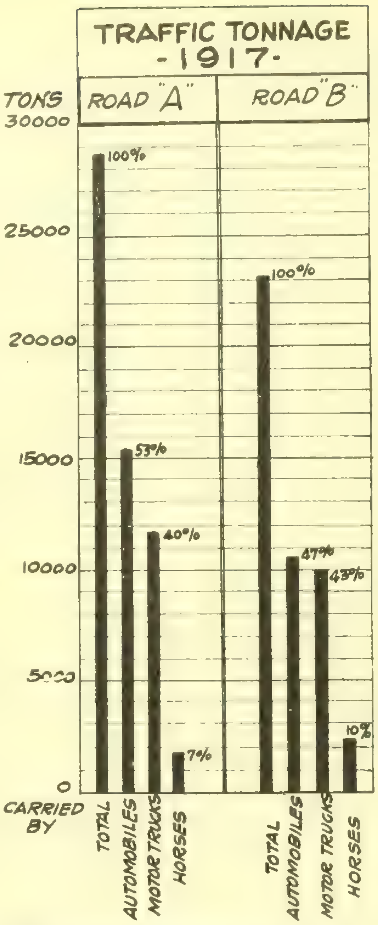
Hades is Paved With Good Intentions.
Do Your Bit Now. Buy W. S. S.



ON THE PHILADELPHIA PIKE, FROM TOP TO BOTTOM, 1, 2, AND 4 MILES NORTH OF WILMINGTON, DEL., MACADAM SURFACED, 16 FEET, WITH BITUMINOUS MATERIAL, 1914. SUBGRADE SAND ROCK CLAY. DRAINAGE GOOD. THIS ROAD CARRIED THE ORDINARY TRAFFIC WITH MODERATE MAINTENANCE. ITS CONDITION AS SHOWN IS THE RESULT OF THE PASSAGE OF A FLEET OF 100 HEAVY TRUCKS.

the single] truck should be limited and any load over a certain amount should be carried on trailers, thus distributing the weight.

Until recently the problem in highway construction has been to build roads that would withstand the various kinds of ordinary traffic. This no longer seems to be the case. We are fast approaching the time when the problem of road construction will be to provide roads that will meet the demands of heavy auto-truck traffic. It seems quite obvious that roads which will carry heavy trucks will stand up under any of the other types of the present-day traffic; therefore it is the truck traffic that should command the attention of the highway engineers.



TWO BITUMINOUS MACADAM ROADS "A" AND "B" WHERE THE PERCENTAGE OF TRUCK TONNAGE IS PRACTICALLY THE SAME.
THE MAINTENANCE WAS NORMAL UNDER THE CONDITIONS

FACE CHART 1.

Now the question arises, if the States, counties, and municipalities have been called upon to invest larger amounts of money in order to build satisfactory pavements, or to provide excessive maintenance to those pavements that have already been constructed, and if this high cost of construction and high cost of maintenance is due to the heavy truck traffic, just what would be a proportionate arrangement and just how much of the road upkeep should the heavy motor truck share as its part in maintaining the highways?

It is readily acknowledged that the large increase of motor trucks has been primarily due to the war, and the greater percentage of the heavy maintenance is due to the damage done by these large motor trucks. If heavy motor trucks were to remain in use only during the period of the war, the problem could be treated in some temporary manner; but the motor truck which has been developed during abnormal times has shown that it has solved an economic problem, and this solution assures us that not only for the period of the war will transportation be affected by motor trucks but that after peace is declared the heavy truck will be utilized in transporting freight and express within expanding limits. Therefore, we should not plan for the truck traffic merely during the war period, but we must build and maintain in such a way that our roads will withstand, as permanently as possible, the demands of the future heavy truck traffic.

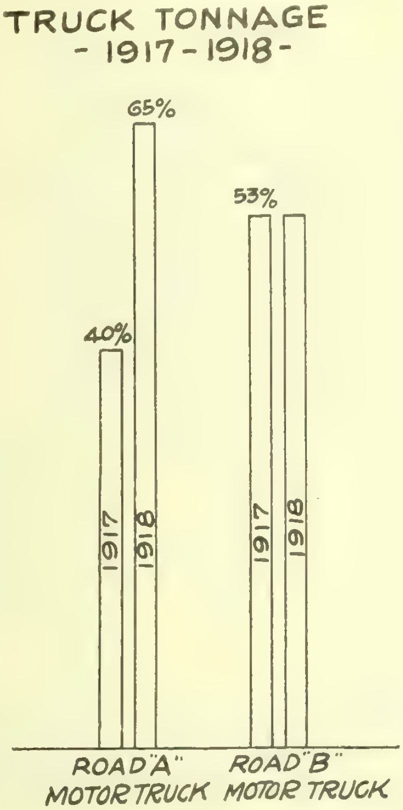
ROAD TAXES AND HEAVY TRUCKS.

In Delaware, previous to 1915, a license for a 20-ton truck would not have cost more than one for a motorcycle, although it can readily be seen that the truck would cause more maintenance than the motorcycle. In 1917 a law was passed which, although far from perfect in making the various types of vehicles pay their proportionate share of the maintenance of the roads, is, however, a step forward in adjusting the tax that should be levied on the various vehicles. This 1917 law is based on the tonnage basis of the vehicle and the expected load. It does not take into account the fact that one truck might be owned by an express company or freight company and be operated day and night, while another of the same rated weight might be used only occasionally. It is evident that the first would cause far more damage to the roads, but both must pay the same license fee.

This points in the direction that heavy trucks should pay the larger part of the road taxes, and this is shown further by data that has been collected relative to this subject, and the experiences of not only Delaware but practically every State.

An example of the damage that the heavy trucks are doing is shown in a road adjacent to Wilmington. This road has been standing the ordinary traffic for three or four years with a moderate amount of maintenance. A manufacturing company purchased a 5-ton truck, loaded it with approximately a 6-ton load, which made the gross load about 11 tons. After this truck began making trips between the factory and the city of Wilmington, the road very soon began to deteriorate, and with the constant hammering of this truck, commenced to break up. As soon as the truck had completed the destruction of the first road and made it too rough to travel, it laid its course over a parallel road between these two points. This road happened to be of lighter construction than the first, and the truck first went over it in the spring when the frost was coming out of the ground. While this road had withstood the demands of light traffic for several years, the first trip of the heavy truck broke it up from one end to the other. A single trip of this truck cost hundreds of dollars of maintenance besides putting the road in such condition that it was too rough for the passage of ordinary vehicles.

Delaware has many miles of macadam road that were constructed and allowed to deteriorate slightly before bituminous coverings were applied. Some of the macadam surface was worn away and the remaining portion was covered with bituminous material. This means that there are now in Delaware many miles of thin-surfaced macadam covered with a bituminous material. This material has been satisfactory for the horse-drawn and light motor-vehicle traffic, but as soon as heavy trucks appeared, these roads which were not capable of standing such heavy loads quickly broke up.



ROAD "A" AND "B" SHOWING THE INCREASE IN TRUCK TRAFFIC ON ROAD "A". MAINTENANCE ON ROAD "A" HAS BEEN EXCESSIVE. TRUCK TONNAGE ON ROAD "B" HAS REMAINED IN THE SAME PROPORTION AND THE MAINTENANCE HAS REMAINED PRACTICALLY NORMAL.

DESTRUCTION BY A SINGLE TRAIN.

A section of the Army transport route between Buffalo and Washington lies in Delaware. On some days as many as 400 trucks have passed over this section which was macadam pavement resurfaced with bituminous material. During the winter, while the road was frozen or covered with snow, trucks had no trouble whatever and apparently did very little damage to the surface. One of the truck trains, however, passed over this section while the frost was coming out of the ground. This one train caused thousands of dollars of damage, and left the road broken up, as shown by the accompanying photographs, which were taken soon after the train had passed. The surface of this road before the trucks had passed was practically smooth and had the appearance of a smooth bituminous macadam. It had been standing up under ordinary traffic with a moderate maintenance. This shows that while these lighter roads are capable of taking care of the lighter traffic, they will not meet the demands of heavy trucks, and we must construct truck roads capable of withstanding heavy truck traffic.

While it has been known for some time that it is the heavy motor truck that is causing great damage to roads, this fact is brought out more clearly by the accompanying charts, which represent the traffic condition on two roads of similar construction.

On Chart 1, Road A, the traffic for an average week showed a total of 11,977 vehicles of all kinds. Road B shows the traffic for an average week ot total 12,411 vehicles of all kinds.

While the number of trucks on each of these roads was practically the same, the truck tonnage hauled over Road A amounted to more than the tonnage over Road B. The percentage of truck traffic over A amounted to 40 per cent, and the amount of truck traffic of the B Road amounted to 43 per cent. Both roads remained in good condition as long as the traffic remained in these proportions.

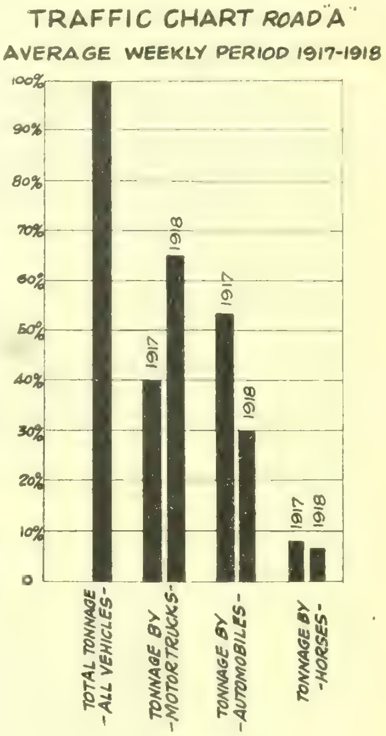


CHART 3

By referring to chart 2, it will be seen that during the spring of 1918 the truck tonnage on B Road remained practically at the same percentage as during the spring of 1917. The truck tonnage on Road A increased to approximately 65 per cent of the total tonnage. The increase in heavy truck tonnage on Road A practically broke up the road for its entire length, and has caused excessive maintenance that has amounted to reconstruction. The maintenance on B Road has remained practically the same for a number of years.

In chart 3 it will be noted that the 1917 traffic shows a greater tonnage of horse traffic and pleasure vehicles than the 1918 traffic, but the heavy truck traffic is greater in 1918 than in 1917. The cost of maintenance thus far in 1918 is considerably more than for the entire year of 1917, or years previous, and this clearly shows that, inasmuch as the horse traffic and pleasure autos have decreased in tonnage, and the heavy auto trucks have increased, that it is undoubtedly the heavy auto truck that is responsible for the high cost of maintenance.

GREATER TAX FOR HEAVIER TRUCKS.

Some have advanced the theory that the license fee for auto trucks should be based on the ton-mile basis. This in itself would be far from satisfactory if no limit were placed on the size of the truck and the maximum load. If there was a limit to the size of the truck and the maximum load, then the greater loads would be distributed over trailers, in which case the ton-mile basis might work to perfection, provided there were some satisfactory means devised for reporting the ton-miles. If there was no limit to the size of the truck, the ton-mile basis would not overcome the great menace, the heavy concentrated loads, for it can be seen at a glance that one 20-ton truck would do infinitely more damage than twenty 1-ton trucks, though the ton-mile tax would be the same. This again shows the reason why the heavier trucks should pay a higher proportionate amount of the road tax.

To stop the building of large auto trucks seems to be standing in the way of progress, but if the cost of maintenance and repair that is made necessary on account of the heavy truck were charged to these trucks themselves, the taxation would be so high that it would be prohibitive, and the use of the heavier trucks would necessarily stop. A large truck can do thousands of dollars' damage to a light road, but we could not expect a truck to pay a license of thousands of dollars.

In view of the fact that there are millions of miles of light pavement throughout the country that will sooner or later be subjected to the demands of truck traffic, it will readily be seen that there will be a great economic loss unless the size of the truck is kept down and made light enough so as not to break down the average pavement we have at the present time.

The problem of truck control is one too large to be handled entirely by the States alone; it is a problem that should not be handled by the truck manufacturers alone, but it should be dealt with in cooperation between the Federal Government, in the control of roads, the State highway departments, the truck manufacturers, and the truck users themselves. From this cooperation and through its sources of information suitable data could be obtained by which the economic maximum size of trucks, the types of satisfactory roads, methods of truck taxation, and traffic regulation could be determined.

It seems quite evident that the width of the truck should be restricted to a certain limit. The excess length, however, does not seem to cause as much concern as any increase over the average width. To allow the width of trucks to expand without restriction, would mean that we would soon be obliged to widen our present-day roads, or reconstruct very wide roads to insure the same safety that now prevails.

The truck trailer has greatly overcome the concentrated loading, and it is quite likely that a more universal application of the trailer will greatly assist in overcoming the heavy loading. To restrict the weight of trucks to a loading that would not injure any of our roads would mean to decrease the size considerably; to allow trucks to go unrestricted over all our roads is going to be very uneconomic; to allow unrestricted trucks the use of all roads and make them pay license fees in proportion to the damage they do would soon prohibit the use of larger trucks; to allow trucks to be constructed larger and larger removes the foundation upon which highway engineers make future plans. A cooperative adjustment of the above factors should present an economic solution of the problem.

There are some roads capable of standing up under 5-ton trucks; others will stand 3-ton trucks without serious maintenance; others will carry the 1-ton truck. Railroads would not send heavy trains over light rails, and why should highways be subjected to loads many times in excess of the loads intended for them?

Until such a time as our trunk-line roads could be brought up to the demands of a standard truck the different highways could be rated, and then any truck in excess of the load that was intended to pass over the highway would not be allowed on that particular road. This would allow heavy trucks on the better roads, and lighter loads on the lighter roads, and would prevent excessive damage to the lighter roads by a few heavy trucks and thus prevent a great economic loss and the destruction of our lighter roads.

New Jersey, One of the Great Sufferers, Plans to Meet Needs of the Future.

By W. G. THOMPSON, State Highway Engineer, New Jersey.

When it is said that New Jersey highways suffered greater damage during the past eight months than during the preceding two years, the statement is hardly exagerated, as roads which for several years presented very good surfaces, became almost impassable under the unprecedented weather and traffic conditions of the past winter. Especially is this condition noticeable along the avenues of heavy motortruck traffic, between the great industrial centers and leading to the seaboard.

It is generally conceded that the geographical position of New Jersey, situated as it is between the great manufacturing States of Pennsylvania and New York, imposes upon it the burden of caring for a greater volume of vehicular traffic than is imposed upon any similar area in the United States. Its seashore resorts attract hundreds of thousands of pleasure and commercial cars during the summer months, while its own enormous industry plus that of its neighboring States pours a never ending stream of heavy motor trucks upon its highways 24 hours per day and 7 days per week. With the entry of our country into the war, this traffic was augmented by thousands of Government motor trucks. All of these classes contribute to the destruction of pavements which were never designed or constructed to bear such heavy, swiftly moving vehicles.

BITUMINOUS CONCRETE ROAD ON THE PHILADELPHIA-NEW YORK MAIN LINE BETWEEN NEW BRUNSWICK AND HIGHTSTOWN N. J., THIS ROAD WAS BUILT IN 1916.

The deterioration of sections of our main trunk highways has been so rapid that the several communities through which they pass have been unable as yet to readjust themselves to enable financing of such a type of construction as will meet the new requirements, though plans and construction are under way by which the counties with their own funds, plus State aid; and the State through its Highway Commission will make strenuous efforts to keep pace with the new and ever-increasing demands.

SUBFOUNDATION DRAINAGE PRIME REQUISITE

The extreme temperature conditions of the past winter have proven beyond any doubt that subfoundation drainage is the prime requisite in maintaining the integrity of foundation and pavement. Ninety per cent of foundation and pavement failures during the past season are directly attributable to lack of, or inadequate, drainage facilities. This is evidenced by the fact that in many instances where, on contiguous sections of road the types of construction were identical, the sections on fill, or well drained, maintained a perfect surface throughout the winter; those sections inadequately drained, heaved and blew up, due to the frost expansion, and in many cases rendered stretches of highway impassable for several days at a time. This condition was unquestionably aggravated by the continuous motor truck traffic, inasmuch as while light cars and wagons might pass safely over such places, the heavy truck would break through the crust, and immediately upon being extricated would be followed by others, until there was formed a veritable quagmire.

ON THE MAIN ROAD, PHILADELPHIA TO NEW YORK, NEAR WINDSOR, N. J. WATERBOUND MACADAM, BITUMINOUS DRESSING BUILT IN 1915. GOOD IN FALL OF 1917 AND CARRYING 172 HEAVY UNITS A DAY.

What is the remedy or answer to this very vital question? Shall there be formulated regulations or restrictions as to the size, weight, and speed of these vehicles, or should the several States permit an unlimited development of this traffic and provide for the construction and maintenance of such roads as will carry it, by the imposition upon it of a tax commensurate with the destruction wrought, and based, perhaps, upon the annual income derived from its use by the owners and operators of such vehicles? It is a question which should be viewed and studied only from the most open and broadminded standpoint, as with the increasing inability of the railroads to meet the transportation requirements, the question of highway transportation is becoming one of the most vital this country has to face. Had it not been for the great volume of freight carried by motor trucks on the highways during the winter of 1917-18, the suffering in the congested centers of population would have been incalculably greater, to say nothing of the facilitating of operations of the military establishment, by this rapid and convenient means of inter city and State communication.

MOTOR TRUCK BUSINESS IN ITS INFANCY.

It is realized by all concerned that as regards volume, the motor truck business is but in its infancy. In New York State the increase in number of trucks during the past three years exceeds 300 per cent. What, then, may be expected during the next five or ten years? Maintenance charges on roads are monthly becoming heavier, and to some communities are rapidly becoming unbearable. It would, therefore, seem that since their number can not well be restricted, their weight and general dimensions should be regulated to a point consistent with the ability of the several States and communities to provide highways and bridges of the requisite strength and width to accommodate them.

In February, 1918, the writer was asked by an operator of a motor truck fleet—who at the moment had two heavy trucks stuck in what under ordinary conditions was a very good road—if he could secure redress from the State for the expense and loss of time occasioned by failure of the pavement to carry his loads. When he was advised he could not, his comments were not complimentary to the system which could not keep its roads in condition to carry the traffic. He saw the matter from his own viewpoint only, and while his was possibly an extreme case, it is indicative of the attitude of many on his side of the question.

Although the motor truck business has its tribulations, it is at the same time a very profitable one, and should assist in defraying the expense of maintaining the highways which, more than any other factor, it helps to destroy, and will continue to destroy, even after heavy foundation and proper drainage facilities have been provided on all the main arteries of communication.

It would be hardly proper or fair at this time to attempt to fix an arbitrary amount which should be paid, based upon the tonnage operated by each owner; as sufficient statistics to enable a proper determination of this matter are not available. New Jersey has a varying scale of fees, effective January 1, 1918, and based upon tonnage, the highest amount being $67 for a vehicle and load weighing from 29,001 to 30,000 pounds. In the writer's opinion this is a very reasonable fee, looked at from the viewpoint of effect of such weight running at speed upon the highway, as the cost of repairing damage resulting from the daily use of the highways by such vehicles will amount to many times that sum during the year.

PLANS FOR NEW CONSTRUCTION.

It is manifest to all who have to deal with the problem that none but the highest type of construction will successfully meet the demands of the traffic to come. As an instance of what may be looked for, there is cited the case of one company now operating a fleet of trucks on regular schedule between Baltimore, Philadelphia, and New York, which will within the year operate no fewer than 60 5-ton trucks over New Jersey highways. This company has a regular repair outfit in a light car, traversing the routes traveled by these trucks, lending assistance and making repairs to such of its fleet as may be stalled on the road. The institution of the "return loads" system will tend to decrease the number of trucks returning empty, thus providing for a greater utilization of the available tonnage, and increasing tonnage to be carried by the pavements.

An expression of opinion as to the kind, cost, and general design of highways is apt to be influenced by the local conditions in any particular region. Generally speaking, the greatest care should be exercised in preparing the subfoundation, and no foundation or pavement should be laid where any doubt exists as to the adequacy of the drainage facilities. In many places, these will cost almost as much as the pavement. On main through routes, it is believed none but concrete foundations should be laid. In New Jersey these will be from 6 to 10 inches in thickness. In many places concrete will be used as a wearing surface; in others, bituminous concrete, laid on a concrete base. Pavements should be not less than 18 feet in width plus a 2 or 3 foot stone shoulder on each side. The New Jersey State highway pavements will in no instance be less than 18 feet wide, will have 3-foot stone shoulders on either side, and a graded width of not less than 30 feet. Maximum grades will not exceed 5 per cent or maximum curvature exceed 6 degrees, except in extreme cases. Pavements of this type will cost from thirty to fifty thousand dollars per mile, exceeding the higher figure in some cases where heavy grading is encountered.

BELIEVES REGULATIONS REASONABLE.

It is difficult to say to what extent existing regulations governing motor truck traffic could be suspended. The operation of large trucks is making it increasingly difficult and dangerous for passenger cars and wagons to use some of our routes, due to the unwillingness of drivers of heavily loaded trucks to keep to the right side of the road, as the fear of overturning or running into the ditch causes the truck drivers to keep to the center of the road. It is the writer's experience that such drivers, due to the noise made by their own machines are often unable to hear the horn of a vehicle approaching from the rear, and will keep to the center of the road, thus preventing lighter, faster cars from passing.

On this account it is believed the New Jersey regulations as to weight and dimensions of trucks are not unreasonable, these limits being: Maximum width, out to out, 96 inches; maximum height, 12 feet 2 inches; maximum length, 26 feet 6 inches; maximum weight at present, 30,000 pounds. But one trailer is allowed for each motor truck, though all bridges on State highways will be designed for 20-ton loads.

It is believed that builders should not be restricted to construction of trucks which existing roads can carry, as but few existing pavements will for long carry the loads now being imposed upon them, but rather that builders should be allowed to put out trucks which would come within the limits prescribed above, and that highway departments should build roads to meet these demands.

The illustrations herewith will give a fairly adequate idea of conditions of the New Jersey highways and the traffic they are called upon to bear. On the main road to New York from Philadelphia between New Brunswick and Hightstown there is a bituminous concrete road 18 feet wide with a 2-foot macadam shoulder. This was constructed in 1916 at a cost of $24,450 per mile. The surfacing is 2-inch bituminous concrete on a base of 6 inches of waterbound macadam, with a clay subgrade. It is not well drained. The condition of the shoulders is fair. Although this road is very heavily traveled, traffic uses the shoulders but little, and this would seem to indicate that 18 feet of pavement is about the proper width for two lines of vehicles. The present traffic over this road averages about 760 vehicles per day, of which 115 are of the heavy-truck type.

Another example on the main road from Philadelphia to New York is a waterbound macadam with bituminous dressing on the road near Windsor. This was constructed in 1915 at a cost of nearly $13,000 per mile. The surface is 3-inch waterbound macadam and 1½ inches of bituminous dressing on a 3-inch macadam base, the subgrade being mostly clay. This road was good in the fall of 1917, but at present is in very bad condition. The surface is worn and pitted, the pavement and foundation being broken through in many places by heavily loaded trucks. Out of an average of 682 vehicles per day traveling over this road, 172 are heavy units.

Four Reasons for Saving and Loaning to the Government: For the Safety of Womanhood, For the Protection of Childhood, For the Honor of Manhood, and For Liberty Throughout the World. W. S. S.

The Higher Type of Construction in the Middle West States Also Fails.

By J. L. HARRISON, Office of Public Roads.

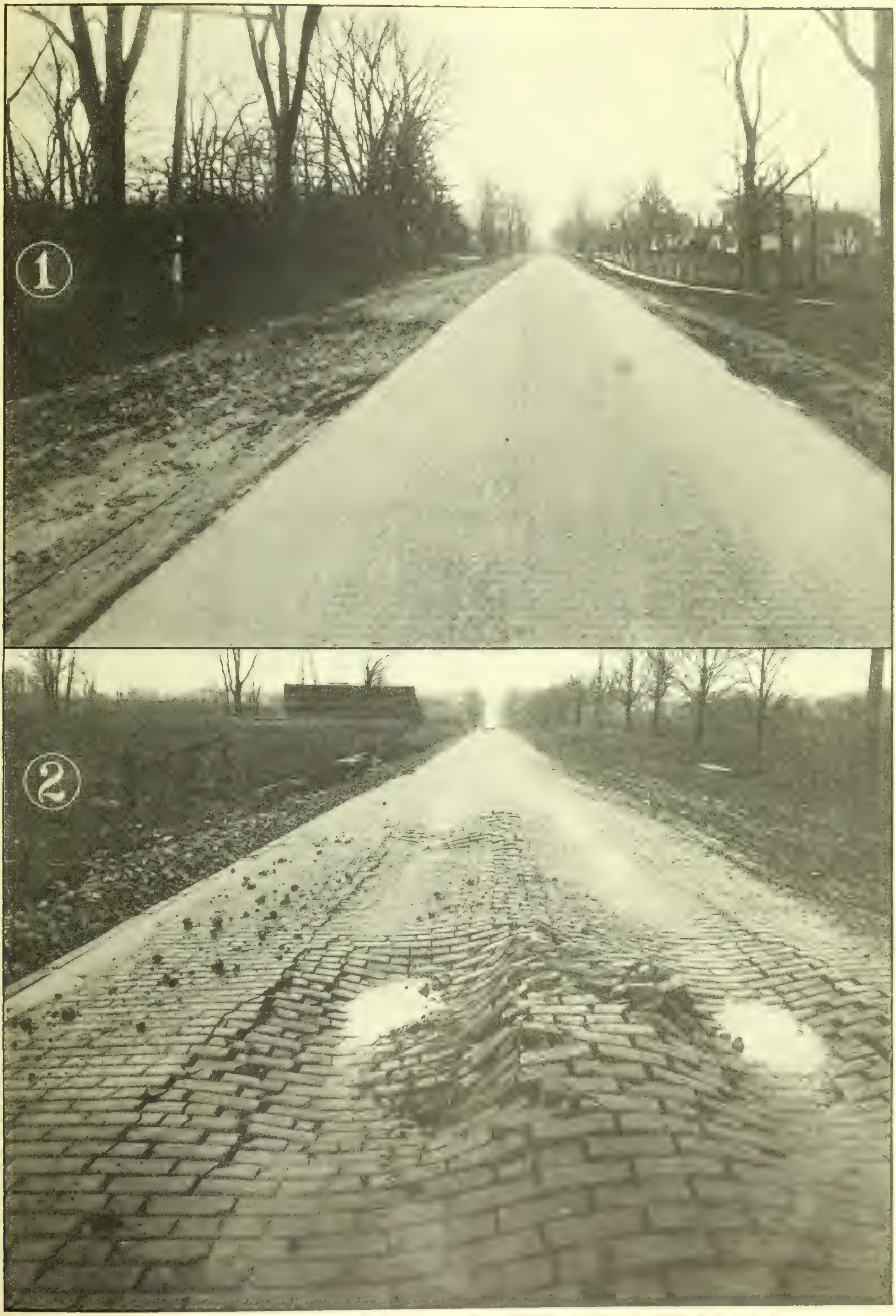
IN the middle West the development of truck traffic in increasingly large units has been more of a city than a country problem. This may probably be traced, first, to the fact that large cities are farther apart than in the East and, second, to the fact that there has been less freight congestion and fewer embargoes to force manufacturers to send their goods long distances in trucks. In studying the effect of the increasing truck traffic in this region one must, therefore, supplement the observations made on country roads by observations made on city streets of the same types commonly used on country roads. In the notes which follow there are references both to city streets and to county highways which are near the cities. Both have suffered severely, and, as nearly as can be observed, no type of pavement is immune from rapid deterioration in the face of the heavy traffic many streets now carry.

Washington Boulevard in Chicago presents a wonderful illustration of the effect of heavy truck traffic on roads having a mixed bituminous top laid on a macadam base, a general type of construction widely used on high-class country highways, as well as on many city boulevards and residence streets. This particular street is a part of Chicago's boulevard system, and no heavy teaming is ordinarily permitted to pass over it. However, after the blizzards of last winter this street was cleared of snow sooner than the regular heavy traffic streets, and in order to assist in the movement of traffic a portion of the street was thrown open to heavy traffic for a period of about three weeks. Before this happened the surfacing was in splendid condition, but as a result of the truck traffic which passed over it during this period much of the surfacing has been damaged, and there are considerable areas where the asphalt top has entirely disappeared and where the trucks have removed the macadam base to a depth of a number of inches. The present appearance of the street justifies the impression that the major trouble was in the macadam base, which, though thick enough,to carry the loads, was not stable enough under heavy load to properly support the asphalt top. This pavement is singled out for special comment because the type is a common one, and the results of a brief period of very heavy loading gives an unusually fine opportunity to judge what effect heavy loadings may be expected to produce on such pavements, whether laid in the city or on country roads.

The larger part of the mileage of the county roads around Chicago is macadam, and the truck traffic over them has not yet reached the proportions now to be observed in many other parts of the country. However, West Lake Street and other main outlets all showed the absolute inadequacy of the macadam pavement in the face of heavy truck traffic, for in spite of careful attention and heavy expenditures for maintenance, repairs, and reconstruction, the surfaces of many of these roads were full of pot holes. In the region around Chicago many of the roads are as much as 18 inches thick, but in spite of constant resurfacing fail to stand up in the face of severe truck traffic simply because the heavy loads wear out, grind up, and crush the stone in the surface of the road at such a rapid rate. Moreover, the internal wear in a macadam pavement, always high, is greatly increased by heavy loadings. The load is transmitted downward largely by the friction between the points and edges of the stones which are in contact. Heavy loads overstress these points and edges of contact, which are consequently crushed, the result being that there is constant internal movement in a macadam pavement subjected to heavy loadings, constant abrasion, and much crushing of particles lying even at some distance below the surface.

As a result of this it is natural to expect that such coverings as bituminous mats, penetration tops, and even mixed tops will fail rapidly under heavy traffic when laid on macadam bases. Washington Boulevard has already been mentioned. The Cook County highways which have been surface-treated reveal the same tendency. In general, there is little evidence of poor foundations, but a great deal of evidence of the fact that macadam as a pavement or as a base under a pliable top has a definite load-supporting limit which is dependent upon the hardness of the stones of which it is composed but which, for most classes of stone can be and, in fact, is being exceeded by the loads now permitted to operate freely over the public highways.

The conditions in and around Indianapolis lead to much the same conclusion. The macadam county roads which were inspected were uniformly in bad condition, due to the evident crushing of the surface material accompanied by the grinding action which takes place under the wheels of heavy vehicles and, of course, by dissipation of the dust and binder. For the most part there is no evidence of raveling, which is the usual method of failure where the stone is hard enough to resist crushing strains and abrasion, but where the dust is drawn off by fast traffic and dissipated by the wind. The difficulties ob-



BRICK ON 4 INCHES OF CONCRETE ON THE CLEVELAND-AKRON ROAD NEAR ADSON, OHIO. AT TOP, PAVEMENT STILL IN GOOD CONDITION. BOTTOM: NEAR TWINSBURGH, BASE HAS FAILED, THOUGH BRICK ON THE TOP ARE STILL IN GOOD CONDITION EXCEPT WHERE DAMAGED BY FAILURE OF THE BASE.

served here, as in Cook County, showed themselves in pot holes and indicated the crushing of the surface material under heavy loads.

Detroit is, in a peculiar way, the home of the automobile. No other city in the world makes as many motor vehicles and probably no other city of anything like its size has a street traffic composed so large of motor vehicles. This also applies to Wayne County, in which Detroit is located. Furthermore, owing to the peculiar street layout, the greater part of the city traffic is concentrated on the avenues which radiate from the center of the city much as the spokes of a wheel radiate from the hub and is delivered to the county road system over the county's extensions of these same avenues. Some idea of the intensity of this traffic may be gained from the fact that a recent traffic count showed a daily average of 6,203 autos and teams on Gratiot Avenue and 8,920 on Jefferson Avenue. This count was taken in the city, but the traffic on the county's extensions of these avenues is almost as heavy. The head of the street repair department is authority for the statement that of trucks alone the number passing along some of Detroit's business streets runs into the thousands every day. It is not surprising, then, that the city streets show the effect of this traffic. In many places bricks have been placed in holes on bituminous surfaces as a temporary expedient pending proper conditions for repairs. Wood block pavements show marked indications of over strain and even hard surface pavements show the effect of excessive loadings. Thus on Michigan Avenue, as far out as the new Ford plant, a concrete pavement, built some years ago by Wayne County, and which was in good condition when seen some months ago, has been so badly broken up during the past winter that it is to be resurfaced, and the results here and in other places observed have led the Wayne County officials to plan on an increase in the thickness of their concrete pavements to 7 inches at the edges and approximately 9.2 inches at the center for their standard 18-foot surface.

The same general conclusions seems to have been arrived at by the city's engineers for it is understood that in Detroit 8-inch concrete bases will hereafter be used under the pavements on all heavy traffic streets. To farther protect the highways of all sorts it is planned to secure legislation requiring that all trucks must be provided with rubber tires. It is thought that in this way the gross weight of truck and load can be kept down to about 12 tons. That some remedial action is necessary is evident, but whether this is the proper course or offers adequate remedy remains to be seen.

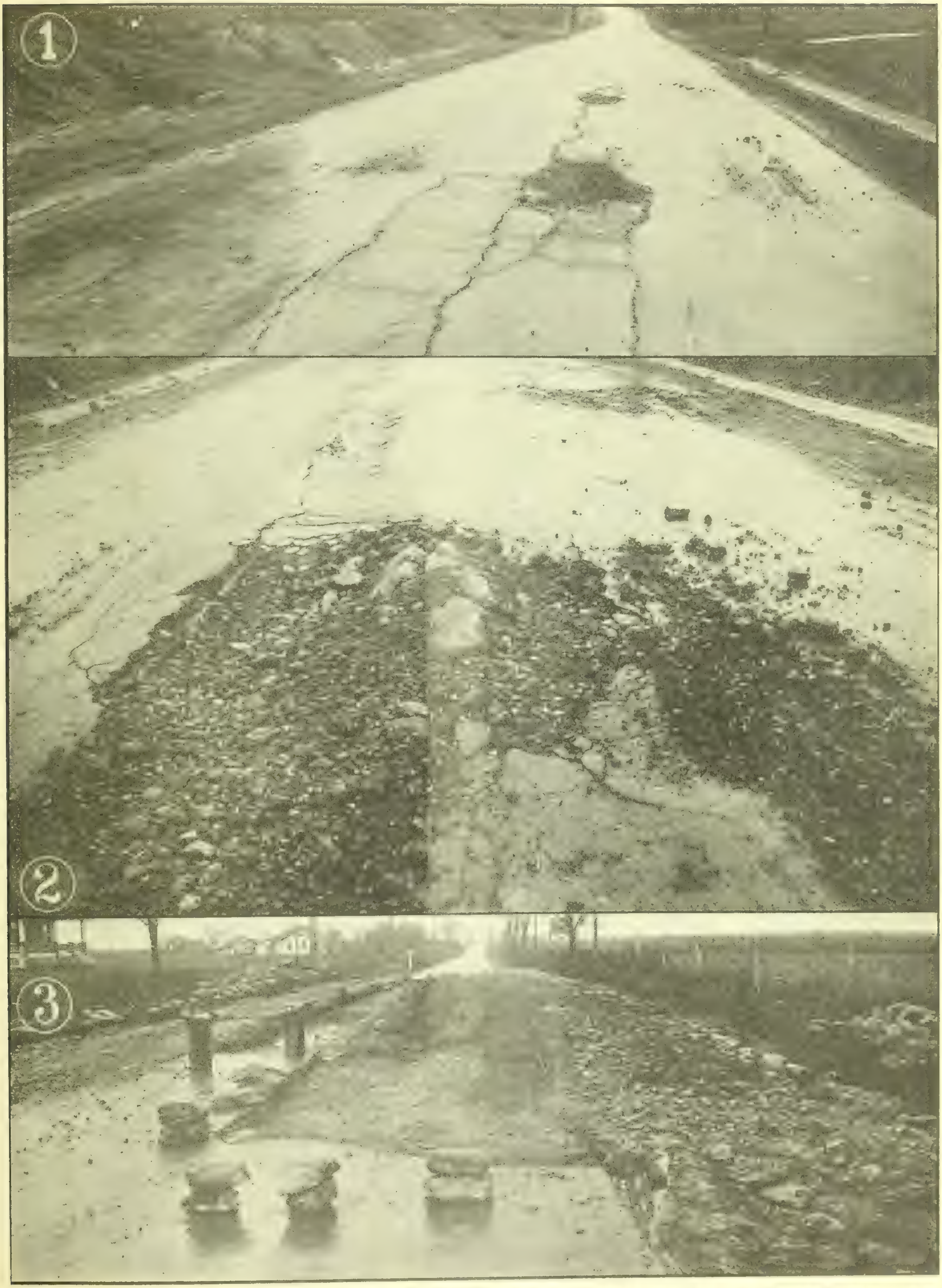
In Cleveland, as in the other cities, there is plenty of evidence that pavements are being overloaded. However the most picturesque illustration of the effect of overload is not in the city itself but is found on the highway between Cleveland and Akron. This is a well constructed, modern highway connecting Cleveland and Akron. Most of the highway is of brick on various kinds of bases, but there is one section of some 2 or 3 miles which is a mixed bituminous top on a 1–2½–5 concrete base 5 inches thick on the edges and 6 inches thick at the center. This pavement has been broken up and broken through in considerable stretches throughout its length. Illustrations show the nature of these failures. In some other places along this road a 4 inch concrete base under a brick pavement has failed so extensively that it has been necessary to tear the old base out entirely and lay a new base to carry the brick surfacing. The brick have not been damaged by the traffic but the base has been badly broken up.

The loads hauled over this highway are very heavy, in isolated cases being reliably reported as reaching 16 tons on a truck weighing 6 or 7 tons, or a gross weight of about 23 tons. Much of the traffic is in units the gross weight of which will run from 10 to 15 tons. Beside this there is a heavy automobile traffic over the road and much lighter trucking.

In this case the trouble differs from most of the other cases observed for here there is no particular evidence that the traffic is damaging the surface of the road where the base and the sub-base are solid enough to support the loads. In fact many sections of this road are still in good condition, though most of the heavy traffic being through traffic, all of the pavement has been subjected to practically the same amount of heavy traffic. The utter failure of some sections of this highway is patently due to the fact that they have been overloaded and the heavy concrete bases literally smashed to pieces by excessive loads.

Experimental Roads Break Down Under Pounding of Excessive Loads

EXPERIMENTAL roads constructed in the vicinity of Washington by the Office of Public Roads and Rural Engineering, have undergone an experience no different from that of roads in other parts of the country. The Rockville, Md. pike, built in 1913, is a water-bound macadam road 6 inches thick, covered with various types of bituminous mats. It has been carefully maintained and, until this spring, has given good service at a reasonable maintenance cost. Within the past three months, however, the motor traffic over this road has increased rapidly with the result that many holes have been formed in the surface and that maintenance costs have increased greatly. The



BITUMINOUS MIXED TOP ON A 6-INCH CONCRETE BASE. PORTION OF THE CLEVELAND-AKRON (OHIO) ROAD. 1—SHOWS FIRST STAGES OF FAILURE; 2—SAME PAVEMENT, FAILURE COMPLETE BUT NOT YET BROKEN THROUGH; 3—SAME PAVEMENT, TYPICAL COMPLETE FAILURE SHOWING RUTS IN THE SUBGRADE. IN THE FOREGROUND REPAIRS HAVE BEEN STARTED.

nature of the holes indicates that in some places the loads are crushing the stone under the mats and that in other places the excessive weight of the loads has driven the stone down into the subgrade thus causing rutting and then breaks in the surface.

So far as can be determined, the mats on the surface of this road have all resisted destruction under truck traffic in about the same manner. All have protected the underlying surfacing to some extent but none has prevented its destruction.

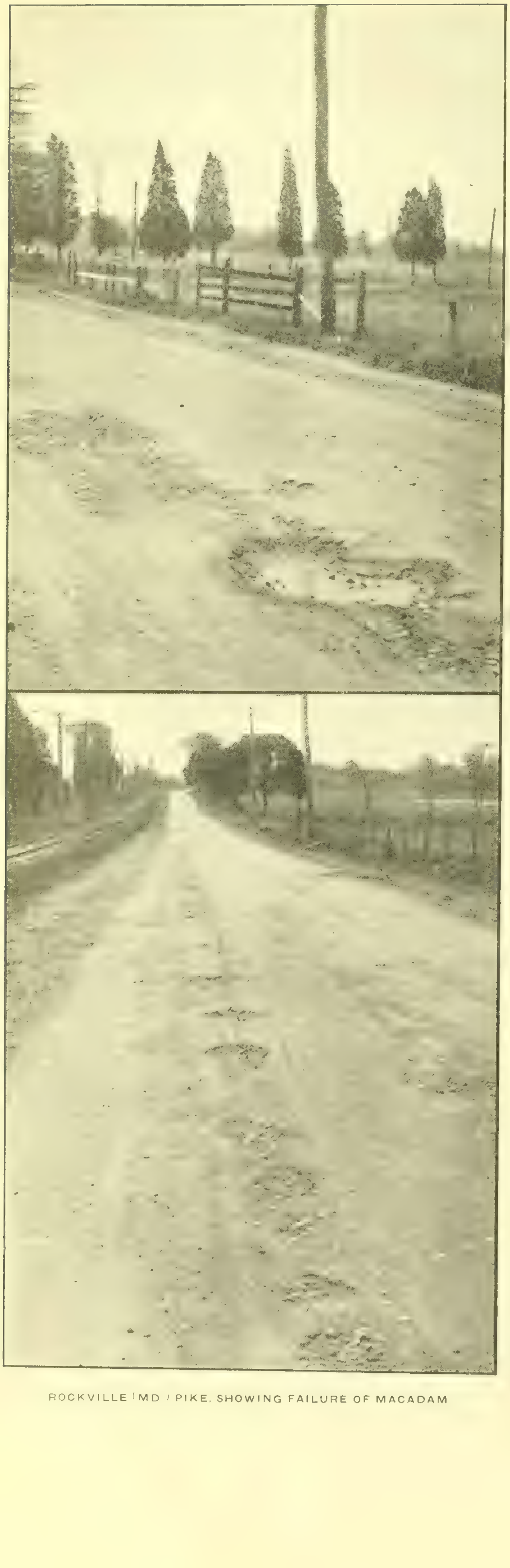
ALEXANDRIA-GUM SPRING ROAD

The road from Washington to Alexandria was built in 1915 as an experimental road, the purpose of its construction having been to determine the efficiency of certain forms of bituminous construction. The sections are all bituminous macadam and bituminous concrete, and bituminous gravel concrete tops on gravel and macadam bases and include some twenty types. (For a full description see Bulletin No. 407 U. S. Department of Agriculture.)

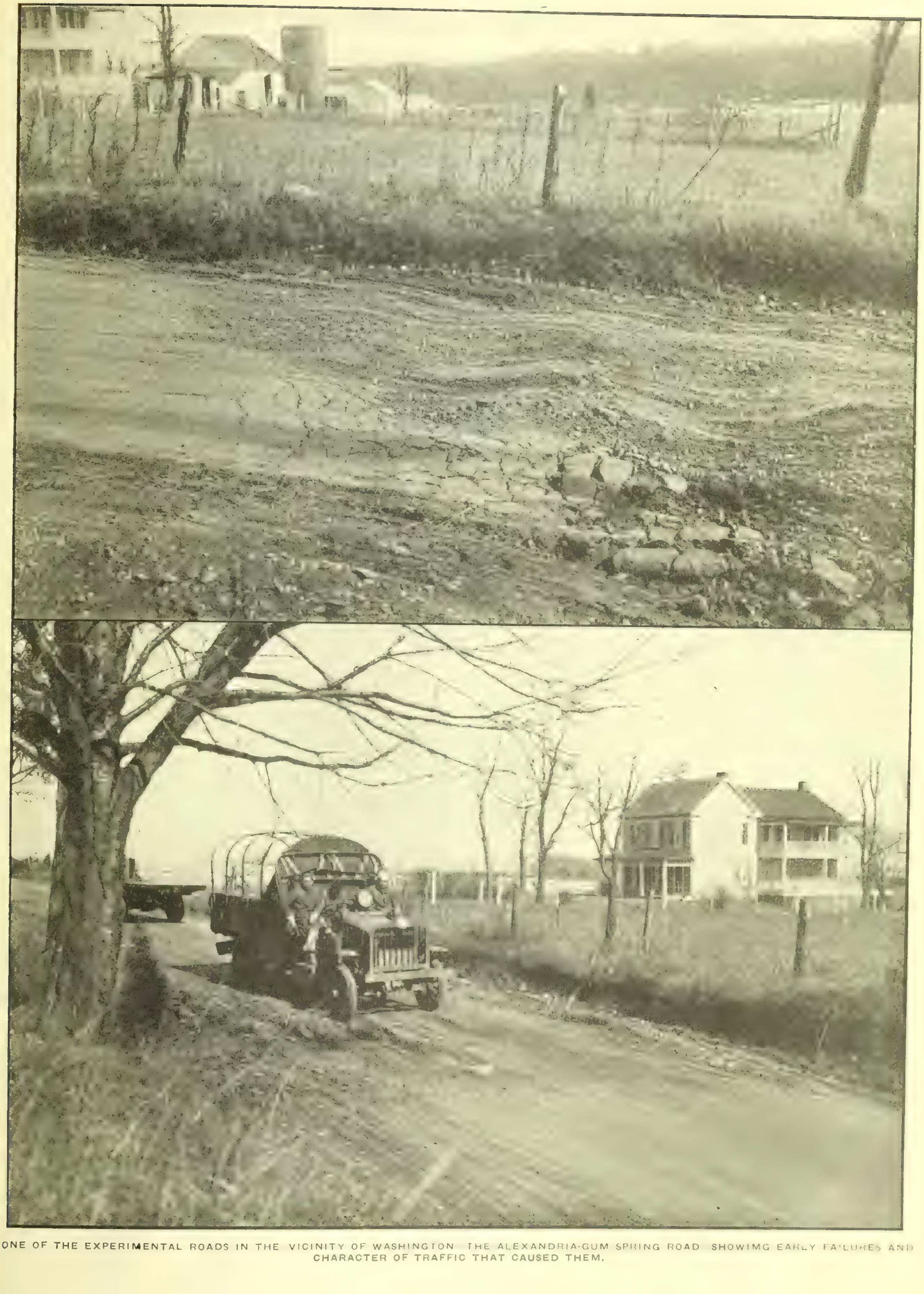
The road from Alexandria to Gum Spring was originally improved during 1914–15, having then been surfaced with 7 inches of gravel 14 feet wide. During 1916–17 this road was reshaped and covered with experimental surfacing to a total length of 25,100 feet. For a distance of 24,500 feet a bituminous gravel concrete top 2 inches thick was then laid over the prepared gravel base, and for a distance of 600 feet an earth-oil asphalt top was laid. A detailed description of these tops and the methods of laying them is contained in Bulletin No. 586 of the United States Department of Agriculture.

About the first of the year the construction of Camp Humphries led to the transportation of a large amount of building material over these roads especially between Alexandria and Accotink. Traffic records show that as many as 508 trucks per day used the Accotink road. As a result of this traffic the road failed rapidly and so completely that it was abandoned as an experimental road and turned over to the Army engineers for maintenance and repair, as it is being used almost wholly for military purposes. The failure of this road has been so complete that no effort is being made to maintain it as a bituminous road. It has been converted into a plain gravel road and is now maintained as such by the War Department.

The road from Washington to Alexandria did not fail as completely as the traffic over it was not as heavy. However, it was broken through in so many places that in order to prevent its complete destruction the driving of trucks over it has been prohibited and there is now a fine of $100 for violating this order.



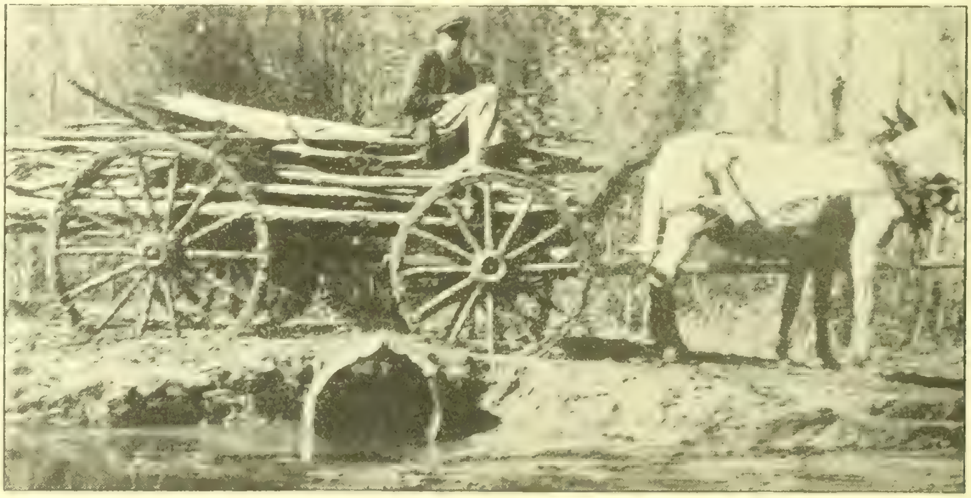
ROCKVILLE (MD.) PIKE, SHOWING FAILURE OF MACADAM



ONE OF THE EXPERIMENTAL ROADS IN THE VICINITY OF WASHINGTON THE ALEXANDRIA-GUM SPRING ROAD SHOWIMG EARLY FAILURES AND CHARACTER OF TRAFFIC THAT CAUSED THEM.

FEDERAL AID PROJECTS APPROVED.

"MODERN" DRAINAGE ON AN ALABAMA FEDERAL AID PROJECT.



The accompanying photograph, taken on a Federal aid project in Alabama, shows some existing drainage conditions and the great need for road improvement in this section. The "modern" drainage structure portrayed consists of a hollow gum log, which it is proposed to replace by an 18-inch tile pipe with concrete head walls. The present condition of the road is clearly indicated by the appearance of the wagon.

The present location is through a swamp filled in with logs and sawdust from a near-by mill and is practically impassable for any but the lightest loads.

This is a fair sample of conditions existing on many roads in the South and is the cause of widespread interest in the securing of Federal aid.

In March and April of this year the Secretary of Agriculture approved 212 Federal aid projects submitted by the States. Sixteen plans, specifications, and estimates covering as many of these projects also were approved. The total mileage involved was 2,530.13. To make these improvements the States estimated that they will have to spend $15,651,112.72, toward which Federal aid to the extent of $5,332,336.34 has been allowed. Including projects acted upon up to March 1, the grand totals are: Projects approved, 475; mileage, 5454.84; estimated cost, $34,337,600.34; Federal aid allowed, $13,215,745.55.

Texas leads in the number of projects approved, in mileage, and in the amount of Federal aid allowed. The State has 41 projects passed upon favorably covering 545.195 miles. It estimates that it must expend $2,275,194.13 with a Federal aid allowance of $1,007,350.39. In point of expenditure, however, Texas is outstripped by Kansas, which proposes in six projects of brick, concrete, and macadam construction covering 108.2 miles to expend $2,336,286.85 under Federal allowance of $350,443.02. Kansas also has the high-expenditure single project of $852,032.50 for 27½ miles of brick construction in Barton County.

Twenty-eight projects involving 125.1 miles were approved for Wisconsin. The State estimates that this will cost $969,847.10, toward which the Federal Government agrees to contribute $323,282.57. Minnesota, in 11 projects undertakes to approve 283.9 miles at a cost of $775,424.22 with Federal aid of $325,865.40. North Dakota had 19 projects approved. These 7,265.61 miles for which it is estimated $364,085.44 will be expended, with $184,042.69 Federal aid.

Though Indiana had but two projects with a total of 16.05 miles, the proposed construction is brick or concrete and will cost $533,030 with Federal aid of $200,500.

The largest single item of Federal aid allowed was $157,216.89 for 48.45 miles of earth to be built in Oregon at a cost of $400,433.79.

The following tables give a complete detailed record of all Federal aid action upon projects during the months of March and April.

ACTION ON FEDERAL AID PROJECTS DURING THE MONTHS OF MARCH AND APRIL, 1918.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	10	Butler	8.07	Sand-clay, or top soil		Mar. 16	$27,071.65	$13,535.82
	23	Coffee	9.305	Sand-clay		Mar. 13	23,304.35	11,652.18
	26	Cleburne	3.48	Gravel		Apr. 30	23,296.46	11,648.23
	27	Lauderdale	4.00	Chert		Apr. 13	24,000.00	12,000.00
	29	Tuscaloosa	6.03	Gravel		Apr. 25	19,885.25	9,942.62
Arizona	2	Maricopa	3.78	Concrete	Apr. 17		77,077.00	37,800.00
	4	Yuma	50.68	Earth	Apr. 18		128,700.00	64,350.00
Arkansas	13	St. Francis	4.94	Gravel	Mar. 14		26,180.00	5,467.10
	14	Jefferson	5.17	do	Mar. 19		21,400.50	10,000.00
	15	Prairie	4.50	Bituminous gravel	Mar. 25		25,197.83	10,000.00
California	10	Modoc	10.85	Earth	Apr. 13		69,188.35	34,594.17

ACTION ON FEDERAL AID PROJECTS DURING THE MONTHS OF MARCH AND APRIL, 1918—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Colorado	2	Huerfano and Las Animas.	77.00	1 mile brick or concrete, balance gravel or macadam	Mar. 19		$260,191.91	$130,095.95
Delaware	1	New Castle	6.20	Brick	Apr. 13		493,009.00	31,000.00
Florida	1	Okaloosa	10.45	Sand-clay		Apr. 25	34,083.28	17,041.64
	2	Osceola	4.12	Brick		do	69,678.53	20,000.00
Idaho	3	Custer	20.00	Earth	Apr. 18		69,425.00	23,000.00
	4	do	1.33	do	do		8,052.00	2,000.00
	5	Lemhi	38.00	do	Apr. 13		299,787.40	135,000.00
	7	Custer	18.00	do	Apr. 18		76,034.00	25,000.00
Indiana	3	Johnson	3.75	Brick or concrete	Mar. 6		99,435.00	37,500.00
	4	Putnam and Hendricks	7.25	do	Mar. 22		189,000.00	72,500.00
	5	Wayne	1.50	do	Mar. 6		47,300.00	15,000.00
	6	Clay and Vigo	4.25	do	do		107,520.00	42,500.00
	8	Hamilton	3.30	do	Mar. 8		89,775.00	33,000.00
Iowa	10	Calhoun	18.40	Gravel	Mar. 30		80,608.00	22,297.55
	14	Harrison	18.20	Earth	do		69,740.00	27,803.60
	16	Montgomery	16.00	do	do		57,266.00	16,557.20
	18	Clinton	18.30	Gravel	do		89,991.00	27,686.45
Kansas	2	Labette	44.50	Gravel or macadam	Mar. 26		510,099.39	76,514.91
	3	Barton	27.50	Brick	do		852,032.50	127,804.87
	4	Shawnee	10.00	Concrete	do		273,400.60	41,010.09
	6	Bourbon	6.39	Macadam	Apr. 29		50,175.75	7,526.36
	7	Douglas	18.34	Concrete	do		444,510.00	66,676.50
	11	Sedgwick	7.375	do	do		206,068.61	30,910.29
Massachusetts	7	Hampshire	4.61	Macadam	Mar. 5		123,890.80	46,100.00
	8	Worcester	6.896	Bituminous macadam	do		163,374.00	68,960.00
Michigan	11	Alpena	5.52	Gravel	Apr. 6		43,356.50	21,678.25
	12	Iosco	9.718	do	Mar. 4		66,000.00	33,000.00
	13	Livingston	6.382	do	Mar. 13		91,533.20	40,136.50
	14	Barry	4.399	do	Mar. 4		47,512.57	23,756.28
	19	St. Joseph	3.97	do	do		42,978.65	21,489.32
	20	Van Buren and Kalamazoo	5.585	Concrete	Mar. 22		137,960.24	55,850.00
	21	Kalamazoo	6.00	do	Mar. 19		110,724.40	55,362.20
Minnesota	1	Pine	50.00	Gravel		Mar. 26	172,150.13	80,000.00
	9	Sherburne	8.00	do		Apr. 25	34,334.06	15,000.00
	14	Carver	26.5	do	Apr. 9		49,280.00	20,000.00
	16	Anoka	17.1	Macadam	Apr. 13		91,731.20	45,865.40
	19	Goodhue	4.6	Gravel	Apr. 9		20,000.00	10,000.00
	24	Morrison	52.6	do	Apr. 29		127,600.00	50,000.00
	27	Douglas	37.5	do	Apr. 24		76,194.80	25,000.00
	28	Grant	5.00	do	Apr. 17		22,000.00	10,000.00
	30	Wright	27.2	do	Apr. 13		83,600.00	30,000.00
	31	Kandiyohi	24.0	Earth	Apr. 29		37,070.00	15,000.00
	32	Lyon	31.4	Gravel	Apr. 13		61,464.03	25,000.00
Mississippi	14	George	13.8	Sand-clay	Mar. 30		20,955.00	10,000.00
	16	Simpson	8.4	Gravel	Mar. 5		20,313.09	10,000.00
	20	Walthall	16.8	do	Apr. 29		60,857.50	20,000.00
	23	Pontotoc	2.5	Macadam or gravel	do		16,707.73	6,500.00
	24	Marshall	6.76	Slag or gravel	do		21,332.47	10,000.00
Missouri	4	Boone	3.00	Bituminous macadam	Mar. 18		21,458.36	10,729.18
Montana	2	Wibaux	17.00	Gravel	Apr. 18		22,440.00	11,220.00
	3	Carbon	3.00	Gravel	Apr. 22		16,412.00	8,206.00
	4	do	3.50	do	Apr. 29		15,600.20	7,800.10
Nebraska	1	Lancaster	5.44	Brick		Mar. 25	205,844.87	35,695.00
	3	Hall	32.10	Earth	Mar. 5		39,531.58	19,765.79
	4	Cedar and Wayne	61.25	Sand-clay	Apr. 25		59,525.51	25,698.75
	5	Madison and Platte	52.25	Earth and sand-clay	Mar. 7		53,166.52	26,583.26
	7	Kearney, Adams, Clay, and Nuckolls.	84.50	Sand-clay	Mar. 5		86,773.52	43,386.76
	10	Lincoln	19.00	Earth	Apr. 13		45,100.00	22,550.00
	12	Logan and McPherson	17.5	do	Apr. 9		20,878.00	10,439.00
	16	Kimball and Bonner	26.5	do	Apr. 6		25,575.00	12,787.50
New Hampshire	[1] 10	Grafton and Merrimack	1.55	Gravel	Mar. 6		16,007.31	8,003.65
	[1] 11	Merrimack	1.52	do	Mar. 5		9,937.84	4,968.92
	12	Rockingham	1.75	do	Mar. 6		11,989.89	5,994.94
	14	Coos	.95	Bituminous macadam	Apr. 6		15,150.82	7,575.41
	15	Merrimack	1.73	Gravel	Apr. 25		11,979.44	5,989.72
New York	6	Rockland	5.57	Concrete or macadam	Mar. 14		110,000.00	55,000.00
	7	St. Lawrence	3.5	Bituminous macadam	do		55,000.00	27,500.00
	8	Wayne	3.21	Bituminous macadam or concrete.	do		63,900.00	31,950.00
	9	Fulton	1.06	Macadam	Apr. 6		20,950.00	10,475.00
North Carolina	19	Rockingham	8.22	Top-soil	Mar. 2		24,218.96	10,000.00
	20	Yadkin	7.00	do	do		16,544.44	5,000.00
	21	Person	7.55	Sand-clay or top-soil	Mar. 14		17,934.29	5,000.00
North Dakota	3	Williams	30.5	Earth	Mar. 15		39,658.04	19,829.02
	4	Richland	20.00	do	Mar. 14		13,407.43	6,703.71
	6	Eddy	5.5	1.4 miles gravel, 4.1 miles earth.	do		6,653.53	3,326.76
	7	Stutsman	9.2	Earth	do		12,972.96	6,486.48
	8	Eddy	9.5	Gravel	Mar. 19		23,949.24	11,974.62
	9	Grand Forks	3.6	do	do		11,456.50	5,728.25
	10	Pierce	5.00	1 mile gravel, 4 miles sand-clay.	Mar. 16		7,999.64	3,999.82
	11	Cavalier	7.8	Earth	Mar. 19		7,190.92	3,595.46
	12	Barnes	29.6	4.4 miles gravel, 25.2 miles earth.	Mar. 18		47,775.09	23,887.54
	13	Stutsman	7.9	Earth	Mar. 14		15,080.19	7,540.09
	14	Stark	18.9	do	Mar. 8		18,944.26	9,472.13
	16	Grand Forks	6.9	Gravel	Mar. 19		17,295.12	8,647.56
	17	Griggs	17.5	Earth	Apr. 4		21,707.40	10,853.70
	18	Ramsey	4.51	do	Mar. 18		3,729.17	1,864.58
	19	do	17.1	do	Mar. 26		12,032.90	6,016.45
	20	Wells	18.00	do	do		19,992.50	9,996.25
	21	Bowman	17.7	do	do		15,999.50	7,999.75
	23	La Moure	10.00	do	Mar. 22		11,491.41	5,745.70
	24	Stutsman	26.4	do	Apr. 1		56,749.64	28,374.82
Ohio	8	Knox	4.00	Brick or concrete	Mar. 5		163,893.40	40,000.00
	9	do	2.01	do	do		65,289.13	10,000.00
	10	Wayne	5.00	Bituminous macadam or brick.	do		140,662.50	50,000.00
	11	Ashtabula	11.92	Brick or concrete	Mar. 6		431,790.00	119,000.00
	12	Wayne	6.71	Brick	Mar. 5		170,541.95	50,000.00
	13	Williams	2.05	Macadam or concrete	Apr. 2		49,690.56	14,698.50
	14	do	2.69	Concrete	Mar. 26		66,209.60	19,287.30
Oklahoma	3	Oklahoma	2.04	Brick, concrete, or asphalt	Apr. 6		46,472.80	20,400.00
	4	Comanche	2.68	Concrete	Apr. 24		53,600.00	26,800.00
Oregon	6	Grant and Wheeler	48.45	Earth	Mar. 25		400,433.79	157,216.89

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[1] Withdrawn by Highway Department.

ACTION ON FEDERAL AID PROJECTS DURING THE MONTHS OF MARCH AND APRIL, 1918—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Pennsylvania	5	Somerset	7.45	Brick or concrete		Mar. 29	257,217.07	74,500.00
	6	Blair	3.01	Concrete		Apr. 19	91,319.08	30,100.00
	7	Lawrence	4.98	do		Apr. 1	180,746.50	49,800.00
	8[1]	Erie	5.454	do		Apr. 2	154,962.25	54,540.00
	12	Northampton	5.9	do	Apr. 6		194,700.00	59,000.00
	15	Beaver	11.1	do	do		427,350.00	111,000.00
	16	Butler	3.3	do	Mar. 7		127,050.00	33,000.00
South Carolina	3	Greenville	4.9	1 mile concrete, 3.9 miles topsoil.		Mar. 13	35,540.37	16,502.31
South Dakota	1	Codington	11.24	Gravel	Apr. 6		47,972.10	19,415.84
	3	Grant	11.8	do	Apr. 13		34,127.78	17,063.89
	4	Brookings	6.5	do	Apr. 6		19,946.30	9,973.15
Tennessee	3	Franklin	10.89	Macadam	Apr. 29		83,784.72	40,000.00
	4	Moore and Bedford	12.27	1.37 miles macadam, 10.9 miles gravel.	Apr. 27		78,657.65	39,328.82
Texas	10	Williamson	21.5	Bituminous gravel	Apr. 29		106,375.50	50,000.00
	11	McLennan	1.25	Asphaltic gravel surface	Mar. 16		10,003.07	5,000.00
	12	do	3.5	Bituminous gravel	Mar. 13		25,003.00	12,500.00
	14	Wise	42.3	Gravel	Mar. 30		170,000.00	80,000.00
	17	Mason	24.0	Sand-clay, and gravel	Mar. 18		22,533.50	11,266.75
	18	Franklin	12.15	Gravel	Mar. 14		49,500.00	24,750.00
	19	Eastland	28.3	do	do		117,983.80	35,000.00
	21	Gregg	24.6	Bituminous macadam	do		57,995.72	19,000.00
	22	Dallas	3.00	Surface-treated macadam	Mar. 5		20,401.48	10,200.00
	23	do	3.00		Mar. 22		14,000.00	7,000.00
	24	do	1.00	Concrete	Mar. 5		20,000.20	10,000.00
	25	do	3.00	Surface-treated macadam	do		19,999.98	10,000.00
	26	Titus	8.00	Bituminous gravel	do		56,039.69	28,019.84
	27	do	11.25	do	do		19,800.00	9,900.00
	28	Morris	10.88	Sand-clay	Mar. 16		65,200.54	32,600.00
	29	Val Verde	3.64	Gravel	Mar. 18		25,687.90	12,843.95
	30	Jasper	13.6	do	Mar. 6		71,696.90	30,000.00
	31	Bexar	18.18	Bituminous gravel	Mar. 22		110,080.76	55,040.38
	32	Harris	3.183	Bituminous concrete	Mar. 16		113,221.22	34,602.19
	33	do	4.592	Bituminous gravel	Mar. 19		48,592.50	15,397.81
	34	Dickens	6.5	Gravel	Mar. 16		32,439.00	15,345.00
	35	Guadalupe	15.7	Bituminous gravel	Mar. 18		69,789.50	34,894.75
	36	Caldwell	15.8	Gravel	Mar. 14		77,061.82	35,000.00
	37	Fayette	11.00	Bituminous gravel	Mar. 18		73,546.00	36,773.00
	40	Bell	36.93	do	Apr. 26		99,963.00	49,981.80
	41	Tarrant	10.00	do	Mar. 16		68,740.65	34,370.32
	42	do	6.2	do	Mar. 18		28,619.25	14,309.62
	44	Robertson	5.5	Gravel	Apr. 13		27,890.50	13,945.25
	45	Hemphill	17.00	Sand-clay	Apr. 25		19,646.00	9,823.00
	46	Gillespie	18.6	Gravel	Mar. 22		41,899.00	20,000.00
	47	Collingsworth	10.5		Apr. 24		10,010.00	5,000.00
	49	Nolan	13.7	Gravel	Mar. 19		43,709.60	21,854.80
	52	Callahan	12.1	do	Apr. 9		50,453.70	25,226.85
	55	Camp	8.00	Gravel or macadam	Apr. 6		69,816.00	17,454.00
	59	Victoria	10.00	Bituminous shell	Apr. 10		33,594.00	15,804.00
	61	Wichita	5.12	Bituminous gravel	Apr. 24		46,158.75	12,500.00
	63	Fannin	7.7	Gravel	do		52,714.15	26,357.03
	66	Comal	19.6	Bituminous gravel or macadam.	Apr. 29		41,250.00	17,500.00
	67	Wheeler	34.82	Sand-clay and gravel	Apr. 24		69,330.05	34,665.02
	68	Gonzales	29.5	Bituminous gravel	Apr. 27		119,116.30	59,583.15
	69	Aransas	10.0	do	Apr. 25		55,331.10	13,841.88
Utah	2	Weber	9.6	Macadam	Mar. 7		32,818.75	16,409.37
	4	Emery and Carbon	63.00	Earth	Mar. 5		109,923.00	54,961.50
Washington	7	Lincoln	8.29	Gravel or macadam	Apr. 19		59,827.02	28,768.56
West Virginia	2	Taylor	2.00	Brick	Mar. 30		57,420.00	8,000.00
	4	Marion	2.4	Concrete	do		43,461.00	13,000.00
	5	Monongalia	2.6	do	do		60,247.00	18,000.00
	6	Mineral	0.78	do	do		12,762.25	6,381.00
	7	Wetzel	1.30	do	do		30,319.30	8,645.00
	8	Wayne	2.00	do	do		60,930.00	8,930.00
	9	Jackson	1.00	do	do		19,958.45	9,979.23
	10	Mason	5.89	do	Apr. 6		133,000.00	16,530.00
	14	Mingo	8.00	Earth	Apr. 17		74,525.00	8,075.00
	16	Barbour	3.2	Bituminous macadam	Mar. 30		33,334.40	8,075.00
	17	Brooke	1.00	Brick and macadam	do		30,872.16	6,080.00
Wisconsin	1	Racine	3.2	Concrete		Mar. 5	53,316.94	17,772.32
	2	Manitowoc	0.61	do	Mar. 25		22,161.92	7,387.30
	3	Kenosha	1.5	do	Apr. 18		28,429.50	9,476.50
	4	Shawano	7.33	Gravel	Mar. 22		36,102.00	12,034.00
	5	Oconto and Marinette	6.58	do	Apr. 13		32,232.84	10,744.28
	6	Oconto	3.01	do	Apr. 24		11,706.75	3,902.25
	7	Waukesha	3.66	Macadam	Mar. 19		29,975.00	9,991.66
	8	Dane	3.4	Concrete	Mar. 22		75,622.27	25,207.42
	9	Kewaunee	1.496	Gravel-macadam	Mar. 16		9,152.00	3,050.66
	10	Walworth	1.82	Concrete	Mar. 25		34,518.00	11,506.00
	11	Milwaukee	2.23	do	Mar. 22		51,678.00	17,226.00
	12	Dane	2.73	Macadam	do		29,645.00	9,881.66
	14	Dunn	4.95	Earth	do		12,342.00	4,114.00
	16	Pepin	2.34	Gravel	Mar. 29		13,612.50	4,537.50
	17	Eau Claire and Chippewa	8.83	Concrete or brick	Apr. 26		169,488.55	56,496.18
	18	Oneida	2.00		Mar. 26		7,424.78	2,474.92
	19	Price	6.9	Earth	Mar. 22		20,790.00	6,930.00
	20	Langlade	6.21	Gravel	Apr. 29		38,995.02	12,998.34
	21	Brown	3.807	Concrete	Apr. 24		80,977.87	26,992.62
	22	Polk	15.3	Earth	Mar. 26		35,138.40	11,712.80
	23	Lincoln	4.15	Gravel	Apr. 24		29,699.78	9,899.92
	25	Marquette	4.16	Topsoil	Apr. 29		17,518.60	5,839.53
	27	Forest and Florence	6.29	Earth	Apr. 9		22,499.99	7,499.99
	30	Kenosha	1.43	Concrete	Mar. 25		27,933.67	9,311.22
	31	Taylor	7.05	Earth	Apr. 6		17,594.50	5,864.83
	37	Portage	5.98	Gravel	Apr. 29		23,900.80	7,966.93
	38	Marathon	8.00	do	do		44,908.60	14,969.53
	39	Racine	0.93	Concrete	Apr. 27		21,752.50	7,250.83
	40	Sheboygan	2.41	Bituminous macadam	Apr. 24		24,047.10	8,015.70
Wyoming	6	Converse	7.5	Earth	Apr. 18		7,689.00	3,844.50
	8	Park		Four bridges	Apr. 6		8,564.52	4,282.26
	19	Natrona	42.72	Concrete, sand-clay, and earth.	do		219,735.59	109,867.79
Total	212		2,530.13				15,651,112.72	5,332,336.34

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[1] Sections A and B.

SOME HIGHWAY BUILDERS.

HERE ARE SOME OF THE MEN WHO HELP TO BUILD THE HIGHWAYS OF THE UNITED STATES. FROM TIME TO TIME PUBLIC ROADS WILL PRESENT PHOTOS AND SKETCHES OF OTHER STATE OFFICIALS ACTIVE IN ROAD CONSTRUCTION.

Austin Bradstreet Fletcher, highway engineer of the State department of engineering of California and executive officer of the California Highway Commission, is a graduate of Harvard and of Lawrence Scientific School, from which he received the degree of B. S. in C. E. in 1893. Immediately thereafter he became secretary and chief executive officer of the Massachusetts Highway Commission, which office he retained until January 1, 1910, when he became the secretary-engineer of the San Diego County Highway Commission. He has held his present position since September, 1911, with the exception of a short period on leave of absence in which he was chief engineer of the Office of Public Roads and rural engineer, August and September, 1916. In addition to his other duties he has those of chairman of the State Reclamation Board and member of the executive committee of the State Council of Defense. Mr. Fletcher is a member of the American Society of Civil Engineers, American Society of Testing Materials, American Society for the Advancement of Science, American Society for the Promotion of Engineering Education, American Concrete Institute, Boston Society of Civil Engineers, American Association of State Highway Officials, American Roadbuilders Association, Boston Engineers Club, Harvard Club of San Francisco, and other organizations.

Alexander W. Graham has been State highway engineer of his native State, Missouri, somewhat more than a year. After receiving his degree of B. S. in C. E. from the University of Missouri, he entered the employ of the United States War Department on the low water survey of the Mississippi River. Later, for about five years, he was associated with a firm of consulting engineers in his own State, acting as field engineer on preliminary surveys, borings, investigations, and constructions of bridges, pavements, and street railways. He was resident engineer on some of the largest construction work in the Middle West, among which are the bridges over the Mississippi near Keithsburg, Ill., the Armour-Swift-Burlington bridge at Kansas City, and the Yellowstone River bridge in Montana.

A. R. Hirst, State highway engineer of Wisconsin, was born in New York in 1881. Immediately after graduation from Maryland State College in 1902, he worked six months with the construction corps, Pennsylvania Railroad. Then he entered the employ of the highway division, Maryland Geological Survey, where he remained until 1907 when he went to the Illinois Highway Commission as engineer in charge of construction. A year later found him highway engineer, highway division, Wisconsin Geological Survey, where he remained until the creation of the Wisconsin Highway Commission in 1911, when he became chief engineer of the commission with the title of State highway engineer.

W. S. Keller, B. C. E., University of Alabama, State highway engineer of his native State, began his career in private practice immediately after graduation. After seven years he became assistant engineer of Shiloh National Military Park, where he remained five years, later going as chief engineer to the Madison County, Tenn., Good Roads Commission. Three years later found him superintendent of road construction in the United States Office of Public Roads, then again chief engineer of the Madison County Good Roads Commission. He was county engineer of Dallas County, Ala., for a year and received his appointment as State highway engineer in April, 1911.

Paul D. Pratt, engineer of the State highway department of Montana, has lived in that State for 21 years, and is a graduate, with the degree of Engineer of Mines, from the State School of Mines. He followed mining engineering in Butte until 1907 and then for 10 years was engaged in the practice of general mining and civil engineering in Lincoln County. With the organization of the present State highway commission he received his present appointment.

Clifford Older, chief highway engineer of Illinois, was born in Wisconsin, and graduated from the University of that State 18 years ago. For six years following his graduation he was in the employ of various railways and then became bridge engineer with the Illinois Highway Department, remaining in the service of this department from that time. He was made chief engineer in November of last year.

PENETRATION NEEDLES.

The Journal of Agriculture Research for March 13, 1916, published an article by Charles S. Reeve and F. P. Pritchard of this office in which a new needle for making the penetration test on bituminous materials was proposed. This needle was later adopted as standard by the American Society for Testing Materials. This needle overcame the objection of the commonly used No. 2 sewing needle in that it could be more accurately described and so prepared that all needles would be exactly alike. It was designed to yield substantially the same values as No. 2 needles which had been accepted as standard.

Owing to war conditions and the fact that tool and instrument makers have been overburdened with war work it appears practically impossible at this time to have the manufacture of these needles undertaken commercially and testing engineers and chemists who are desirious of following the recommendations of the American Society for Testing Materials have been unable to locate a supply. The Office of Public Roads and Rural Engineering has, therefore, in an effort to relieve the situation, prepared a number of the needles in its own shops for use in connection with public-service work. These needles will be loaned upon request, but in order that they may be distributed as widely as possible at the start the supply will be limited to one to each laboratory, which may be retained as a standard for the selection of sewing needles which yield the same values.

ADEQUATE RIGHTS OF WAY.

By J. T. BULLEN, District Engineer.

In one of the parishes of Louisiana, the police jury (which is a body having the authority usually invested in county commissioners in other States), about six years ago determined to put an end to the uncertainty of road boundaries or rights of way. Accordingly, they passed an ordinance declaring all roads, then in use by the public, as public roads, and the Louisiana law is so framed that any such roads 10 years after said declaration become public property, unless closed to the public before the expiration of 10 years.

A resolution was also passed that no public road would be granted on any petition unless said petition was accompanied by actual deeds to not less than 40 feet of right of way. It was further required that the parish engineer inspect each proposed new road and report on the adequacy of right of way and feasibility of location for a road.

In the event any property holder along the route of proposed road refused to donate right of way, the police jury required that the other parties interested in opening the new road pay for right of way over objecting property owner or guarantee in writing to pay any costs of condemnation.

This had a tendency to shut off the opening of many useless roads, secured a recorded deed for the new road when opened, and the recorded survey definitely located boundary for all time.

Where heavy fills were necessary, greater widths of right of way were required, and usually not less than 50 feet was secured.

In the South, where the settlement along roads is comparatively thin, now is the accepted time to make economic locations and to obtain rights of way sufficient for future development. With the wide right of way the earth for embankments can be borrowed from the side of road and the borrow pits serve as very useful drainage ditches and to some extent as underdrains and take care of the heavy rainfalls usual to this climate.

County officials everywhere should realize that economic location of highways is of prime importance before the settlement of the country makes the cost of rights of way for correct locations prohibitive. One county in the South spends millions on its highway system and the rights of way are so narrow and crooked that a very large part of the bond issue now being agitated for adequately surfacing the roads must be spent in paying for wider rights of way along better locations.

County authorities frequently lose sight of the fact that the right of way is one of the few things about a highway which, when secured along a proper location, needs no renewal, but is in reality permanent.

THE COMMERCIAL SIZES OF BROKEN STONE AGGREGATES

A report of present practice in the New England and Middle Atlantic States.

By

F. H. JACKSON, JR., Assistant Testing Engineer, and C. W. MITMAN, Aid in Mineral Technology.

IN the summer of 1917, the authors visited a number of representative commercial stone-crushing plants located in the New England and Middle Atlantic States for the purpose of collecting data bearing on those features of plant design and operation which affect the actual sizes of the various grades of broken stone used in road construction and in concrete. This survey comprised the first portion of a general investigation of the subject of commercial crushed stone sizes, which has been undertaken by the Office of Public Roads and Rural Engineering with the object of developing standard sizes and uniform nomenclature for crushed stone aggregates.

The first use of mechanically broken stone in road construction appears to have been as early as 1860, when some paving work was done in the city of Hartford, Conn., with stone broken by means of a newly invented jaw crusher. It was not for many years after this, however, that an attempt was made to screen the product of the crusher into different sizes. In fact, the earliest record the authors have found of the use of a revolving screen for this purpose was as recent as 1890, thirty years after the invention of the jaw crusher. The first revolving screens probably were of the single screen type with one size of holes and were designed solely for screening out material over a given size. The simple expedient of combining two or more screens on one shaft for the purpose of separating the crusher product into different sizes naturally was the next step in the evolution of the industry. During the era of road improvement immediately preceding the introduction of the automobile, when waterbound macadam construction was the principal type of broken-stone road, a 3-section screen was all that was necessary, in the way of screening equipment, to produce the required materials. Furthermore, the nature of the work was such that it was not necessary to pay particular attention to the actual sizes produced other than to see that the material for each course came approximately within the limits specified. The introduction and general use of automobiles, however, has been responsible for the rapid development of many types of bituminous and cement concrete roads designed to meet present-day traffic conditions, which types require special sizes of broken stone, often graded within comparatively narrow limits.

The demand for these special sizes of broken stone has led to the establishment at advantageous points throughout the country of stationary crushing plants designed and equipped to turn out six or seven grades of stone from the same crusher product and with daily capacities running as high as six or seven thousand tons. Unfortunately, the great number of methods or modifications of methods which have been advocated and used in the construction, especially of bituminous macadam and bituminous concrete roads, has resulted in the production of a large number of different sizes of stone for essentially the same kind of work. Thus the crushing plant operator must be equipped not only to supply stone for each type of construction, but he must be ready, on short notice, to change his screen equipment in order to meet possibly minor variations in requirements for size of materials.

Experimental road construction has progressed so rapidly along lines developed by numerous engineers working independently of each other that a multiplicity of minor variations in grading are now being specified for comparatively few actually distinct types of roads. The basis of designating sizes of materials also has developed unsystematically so that distinctly different grades of stone frequently are known by the same name in localities often but a short distance apart, and vice versa. This naturally has caused much confusion in placing and filling orders, often resulting in financial loss to one or both parties concerned. Taking all these facts into consideration, it would seem that maximum efficiency in the operation of stone-crushing plants in general has been prevented by the utter lack of system in adopting and specifying stone sizes in vogue at the present time.

It was with the object of collecting information as to the actual conditions obtaining throughout the country along these lines that the survey of stone crushing and screening plants was begun. It was decided to conduct the investigation by stages, covering a relatively small section of the country at first and then studying and reporting the results obtained before continuing. That part of the country included by the New England and Middle Atlantic States was chosen as the starting point, and each producer in this section, as shown by lists furnished by the United States Geological Survey, was requested to cooperate with this office to the extent of allowing representatives to go over his plants and to collect such information relating to his crushing and screening methods as he was willing to give out. From the replies received a little less than one-half the total number of crushing plants in the sections visited were selected for detailed study. With a total of 90 plants thus chosen, it is believed that a fair representation has been obtained of the practices in vogue for both small and large scale operations on the various types of rock. Of this total, 41 plants in the New England States and 49 in the Middle Atlantic States were visited.

PLANTS INSPECTED.

Beginning in Connecticut, nine plants operating in the trap-rock area in the south-central portion of the State were visited. The scale of operation which probably is most easily illustrated by the daily output of stone, ranged from 100 to 5,000 tons, thus representing plants equipped with from one crusher and one screen to those equipped with as many as nine crushers and seven screens.

The survey in Massachusetts was not so simple as that in Connecticut by reason of the fact that a greater number of rock types occur scattered throughout many sections of the State. Stone-crushing plants, for instance, working in granite rock were visited in the extreme southeastern section as well as in the vicinity of Boston and in the northeastern portion. So-called trap-rock areas were studied in and near Boston and also in the west-central portion, while plants working in rhyolite, dacite (grouped under the name felsite), and sandstone, all located within a 15-mile zone of Boston, likewise were visited. The majority of these plants were of small capacity for one of two reasons. First, and this is true of practically all of the plants working granite, the industry is established primarily for the production of dimension or building stone and crushed rock is produced only from spalls or quarry waste which was of little use prior to the era of cement concrete construction and the bituminous treatment of highways. Second, many of the plants are owned and operated either by the smaller municipalities whose requirements do not justify a large-scale equipment, or by individuals who have a restricted market for their stone because of the lack of railroad transportation facilities.

Vermont, New Hampshire, and Maine are represented by visits to three, two, and one plants, respectively, all working in granite. In four cases, crushed-stone production is subordinate to the manufacture of building stone and hence is not a large operation. In the other two cases, one in Vermont and one in New Hampshire, the quarries are operated by municipalities. The three plants in Vermont are scattered along the east flank of the Green Mountains; those in New Hampshire are situated one in the south-central portion and the other midway of the eastern border of the State; while the Maine plant is located in the west-central portion of the State.

One plant in Rhode Island was visited. This was located in the center of the State. The rock is sandstone of the bluestone variety and is worked on a small scale, the plant having a capacity of about 150 tons daily.

Cutting diagonally across the northern half of the State of New Jersey in a northeast-southwest direction and extending both north and south into New York, Connecticut, and Pennsylvania, respectively, there occurs a rather narrow area of rocks composed of diabase, gabbro, and basalt, generally called trap rock. The well-known value of this type of rock as a road-building material has resulted in its development on a large scale, and many stone-crushing plants are to be found from one edge of New Jersey to the other. Out of a total of 25 or more, 10 were visited and studied. These were chosen so that variations might be noted not only in the scale of operation, but also in the type of rock. In addition to the trap-rock plants, two granite quarries were studied. These occur along a line parallel to but northeast of the trap-rock area.

Whenever the topography would permit, railroad facilities for transportation were included in the equipment, resulting in large-scale operations—i. e., a daily output of crushed stone ranging from 500 to 3,000 tons. This is true of 50 per cent of the plants visited. The balance, without railroad facilities, are dependent upon local trade or that within the radius of motor transportation and therefore are of smaller capacity.

Following the extension of the trap rock area into New York, a visit was made to one of the large crushing plants in Haverstraw County along the Hudson River. The capacity of this plant is rated at 8,000 tons daily. It is equipped with 13 crushers, one with an opening of 66 by 86 inches, and 8 screens. In addition, 10 other plants were visited in New York State, all but one of which are crushing limestone. The exception was a hornblende gneiss quarry, in Herkimer County. Two of the limestone crushing plants are located along the Hudson River, while the remainder are at various points along an east-west line extending from Albany to Buffalo. Here, again, the choice of plants to be studied was based upon variations in rock type and size of operation so that included in the group are plants working in pure limestone, argillaceous limestone, dolomite, and cherty limestones, with daily capacities ranging from 250 to 5,000 tons.

Fourteen plants in Pennsylvania were visited, including five in the eastern, central, and western sections of the State working limestone; three in counties flanking the Allegheny Mountains working siliceous limestone (locally called ligonier); five in a narrow belt extending across the southeastern corner of the State working trap rock; and one in the southeastern corner of the State working a granite deposit. With few exceptions these plants are situated along railroads and are worked on a rather large scale. They produce railroad ballast in addition to their other products. Those plants quarrying limestone of a quality suitable for the manufacture of lime or for flux in steel manufacture, crushed and screened only those portions of the rock strata low in lime content, and as this represents the handling of only a portion of the quarry output, the equipment and capacity is small.

The plants visited in Maryland included two quarrying granite and one trap rock, in Baltimore County; two working in limestone, one near Hancock and the other in the extreme western part of the State. All are operated on a small scale, as they have only a local market and transport their product by motor trucks.

PROCEDURE.

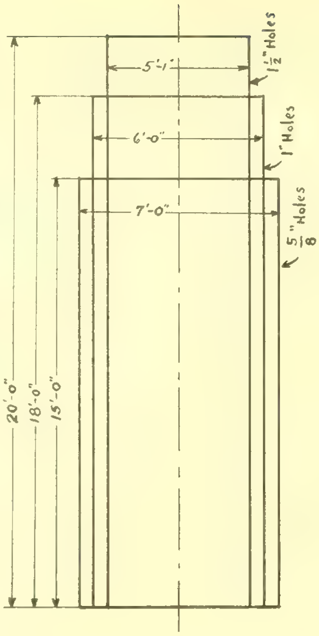
Probably the most important element of the equipment of a crushing plant in so far as quality of grading of output is concerned, is the screen. The present investigation, therefore, centered about this point, but also included other closely related phases of the operation. Thus, the information obtained at each plant included the number, type, and size of primary and secondary crushers; the type, speed, and dimensions of conveyors, and the material each handled, the number of screens in operation, the length over all and diameter of each screen, including jackets, the speed of revolution of revolving screens and their pitch or inclination from the horizontal. In addition, the nominal diameters of the holes (the diameter stipulated when purchasing sections), and the corresponding actual diameter of the holes in each section of the screen at the time of inspection was recorded, together with the total length of each section having the same size of holes. The general arrangements and conditions of chutes for the transfer of stone to bins, and the bins for the storage of stone were noted carefully. A record was made also of each commercial size of stone produced, including the name under which each is sold, the limits of size in which each grade is supposed to lie and, as far as known, the purpose for which each is supplied. Finally, a sample of each commercial size was obtained, ranging in weight from 5 to 25 pounds, depending upon the maximum size of individual pieces. The samples were taken carefully, preferably from an outgoing car, but otherwise directly from the bin, appropriately labeled and forwarded to the laboratory in Washington. As the samples were received, each was analyzed carefully by passing it through a set of screens and recording the weight and the per cent of stone lying between each screen. The screens used were of the standard form, having circular openings of the following diameters: 3 inches, 2½ inches, 2 inches, 1½ inches, 1¼ inches, 1 inch, ¾ inch, ½ inch, ¼ inch. Stone dust and stone screenings were analyzed further by passage through the standard set of sieves used in the analysis of concrete sands. The set includes: 10, 20, 30, 40, 50, 80, 100, and 200 mesh sieves.

DESCRIPTION OF SCREENING METHODS IN USE.

In the course of the field investigations, certain interesting modifications of the elementary revolving screen were noted. These were the result of efforts made by operators to improve the quality of grading of their products. In addition to the ordinary single revolving screen and the single screen carrying a dust jacket over the section with the smallest holes, there were observed complete double and even triple compound revolving screens, as well as various forms of chute and shaking or pulsating screens; the latter introduced usually for the purpose of removing excess dust.

One of the most interesting small operations observed in New England is that of a municipally owned plant in Massachusetts, a few miles north of Boston. This plant works in trap rock and employs a single 26 by 13 inch jaw crusher which feeds to an 18-inch by 60-foot bucket elevator running at a speed of 150 feet per minute. The elevator is set at a very low angle necessitating more buckets for the height attained than usually are employed. It has the advantage, however, of preventing material from falling out of the buckets during elevation, a condition which is observed frequently in cases where the elevator is set at too high an angle. The elevator discharges into a single revolving screen 36 inches in diameter and 12 feet long, containing three standard 4-foot sections with circular perforations of ⅝, 1¼, and 2½ inches in diameter. A dust jacket with ¼-inch round holes and 48 inches in diameter surrounds the ⅝-inch section and the whole revolves at a speed of 13 r. p. m., and is set at an inclination of 1 inch to the foot. This plant, which is typical of a small, single screen outfit, is equipped to turn out four sizes of stone; that between the 2½-inch and 1¼-inch screens; that between the 1¼ and ⅝ inch screens; that between the ⅝ and ¼ inch screens; and that passing the ¼-inch screen. The tailings or that portion retained on the 2½-inch section are returned to the crusher by means of an endless belt and recrushed. To operate the plant requires a 50 h. p. electric motor, and the production is between 100 and 150 tons of stone per working day of eight hours.

The use of double concentric screens may be illustrated by reference to a large and modern trap-rock plant located in the central portion of Connecticut.



This plant is equipped to turn out several thousand tons of stone a day. The initial breaker is a 48 by 72 inch jaw crusher, below which is set a No. 10 gyratory crusher. The product of this gyratory is elevated to a double scalping screen provided with 5-inch holes in the main screen and 2½-inch holes in the jacket. The system thus permits a division of the tailings from this screen into two sizes, those over 5 inches going to one set of crushers and those between 5 and 2½ inches going to another set, while all material under 2½ inches goes direct to the main screen. By this arrangement it will be seen that the tailings can be divided between two sets of crushers set to crush different sizes of stone, thereby considerably increasing the general efficiency of the plant. From the secondary crusher, the stone is again elevated to a second scalper provided with 2½-inch holes, the rejections from which are dropped into a disk crusher. The main screens, which receive all the material passing the 2½-inch openings in both scalping screens as well as the product of the disk, are in two sets, two double screens in each set, placed in parallel. The stone from the crusher house is carried to the first set consisting of two screens having 1¾-inch openings, surrounded by jackets with holes $1\frac{3}{16}$ inches in diameter.

Here are produced the two largest commercial grades, the first being that part of the product retained on the main screen and the second that part of the product passing the main screen and retained on the jacket. The material passing through the jacket is elevated to the second set of screens, each of which consists of a screen having 1-inch holes and surrounded by a jacket having ⅝-inch holes the first half of its length and ⅜-inch holes the second half. This arrangement divides the stone under $1\frac{3}{16}$ inches in size into four fractions, that passing the ⅜-inch jacket, that between ⅜ and ⅝ inch, and that between ⅝ and 1 inch, and finally that between 1 inch and $1\frac{3}{16}$ inches.

A third variation in screening methods is that in use in one of the larger crushing plants in New York State, working in cherty limestone. The stone from the quarry is delivered first to a large gyratory crusher, which breaks it to a maximum size of 4½ inches. The product is discharged directly into a revolving scalper screen 10 feet long and 61 inches in diameter having circular holes 3½ inches in diameter. The stone passing over these holes is recrushed in a second breaker and is elevated, together with the material passing through the scalper, and discharged into a second screen. The holes in this and all subsequent screens are of such a diameter as to give a grading of stone nominally conforming to the New York State Highway Commission's specifications. This second screen is made up of three concentric screens, as shown in figure 1.

The perforations in the inner screen are 3¾ inches in diameter, those in the middle screen 3¼ inches, and those in the outer screen 2¾ inches. At the time of visiting the plant the stone passing the 3¼-inch holes but retained on the 2¾-inch holes dropped directly into a storage bin beneath, while the material above 3¼ inches in size was recrushed. It will be seen, however, that should there be a demand for it stones ranging in size from 3¾ to 2¾ inches may be supplied easily.

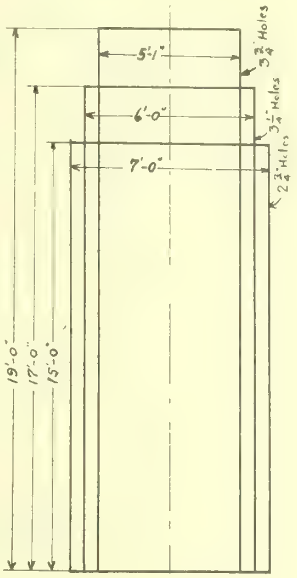
That portion of the crushed stone passing through the 2¾-inch holes is conveyed to a pair of revolving screens, each of which, like the screen just described, is made up of three concentric screens, as shown in figure 2. Here the perforations in the inner, middle, and outer screens are 1½ inches, 1 inch, and ⅝ inch in diameter, respectively. Thus four grades of stone may be produced. The material passing the 1½-inch holes but retained on the 1-inch holes is obtained for a special purpose only, so that usually three grades of stone are produced. These are stone passing the 2¾-inch and retained on the 1½-inch holes, passing the 1½-inch and retained on the ⅝-inch, and that passing the ⅝-inch holes. Each of these sizes is directed to a storage bin under the screens. Should there be a call for stone passing through a ⅝-inch hole, but free from dust, a portion of the stone passing the ⅝-inch holes is removed from the storage bin and charged into a screen 15 feet long and 61 inches in diameter surrounded by a jacket 6 feet long and 72 inches in diameter.

The holes in this screen are ⅝ inch in diameter and those in the jacket ⅜ inch, thus making two additional grades of stone, namely, passing ⅝-inch and not passing a ⅜-inch hole, and all material passing through the ⅜-inch hole.

All five screens are operated at a speed of 14 r. p. m. and have an inclination of 1½ inches per foot of length. To run this whole plant, including three crushers, a pan conveyor, five screens, three conveyors, a balance skip hoist from the quarry, and an air compressor of 1,500 cubic feet capacity, requires a steam plant of 450 boiler horsepower.

The advantage gained by double and triple screens are many, but mention will be made here of only the more obvious. Foremost of these is a large screening area confined within a comparatively short space, thus tending to produce a well-graded stone, and second, the elimination of the congestion and excessive weight of stone, especially at the charging end, and a more even distribution, resulting in a cleaner product and longer life of the individual screen sections.

GENERAL RESULTS OBTAINED.



A comparison of those variations in plant screen design and operation which presumably might influence the grading of the commercial products, and therefore the actual sizes of individual samples as shown by laboratory analyses may be obtained by an inspection of Table I. The plant screen data in each case includes the length, diameter, and size of holes in both the screen section on which the product was retained and that through which it passed. The pitch in inches per foot and the speed in revolutions per minute of each screen also are given. The corresponding laboratory data show the percentage of the weight of the original samples lying between the actual sizes given, based on the use of standard laboratory screens having circular openings. The plants are classified first by States in which they operate, and second, by the type of rock which they handle. They are subdivided further by grouping first all of the plants in the State producing the largest commerical size in general use; second, all the plants producing the next largest size, and so on. The first subdivision in Table I thus shows four plants producing the size stone commonly known as "ballast;" the second, six plants producing stone variously known as 1¼ and 1½ inches, but each sold for use in the same type of construction.

Table 2 shows the total number of tons of all sizes which each plant can produce under average conditions. These capacities were rated by the operators themselves and were not estimated by the observers. It was found practically impossible to obtain any trustworthy data showing the relative amounts of each size produced owing to the fact that changes in screen installation and in the size of crusher opening are being made constantly in order to meet the varying demands of the market. The total horsepower required for efficient operation as given by the operators also is shown. It is recorded, however, only as a matter of additional information and seemingly bears no definite relation to the output of the plant. The discussion of the results obtained may be grouped under four general heads, as follows:

(1) A comparative study of variations in plant screen installation and operation.

(2) A comparison of the nominal sizes for various products as called for by plant screen data with the actual sizes as shown by laboratory analysis.

(3) A comparison of the nomenclature used by the various operators and users of crushed stone in designating the same products.

(4) A comparison of the actual sizes produced with the requirements of State specifications.

VARIATIONS IN PLANT SCREEN INSTALLATION AND OPERATION.

An examination of Table 1 shows, in the first place, that extremely wide variations exist in both the lengths and diameters of the screen sections used. These dimensions are, of course, influenced largely by the scale of operation because the capacity of a revolving screen varies directly with its screening area. Theoretically, also, the length of the screen section should materially influence the grading of the product passing over it, in that the longer the section, the smaller should be the proportion of material retained on it which would pass a laboratory screen with the same size holes. To ascertain whether or not such a relation actually exists the figures in Table 3 were compiled. This table illustrates the comparative efficiency of plant screens of various lengths from 1 to 20 feet. In each case the total number of plants considered is given, together with the per cent of plants which show less than 15 per cent of stone passing a laboratory screen having the same size perforations. It will be noted that in a general way the long screens are more efficient than the short ones so that in almost every case, screens of 10 feet or more in length are 100 per cent efficient, based on a tolerance of 15 per cent, which has been assumed to be a reasonable one.

Screening efficiency, on the other hand, does not appear to be affected by the diameter of the screen used other than that the longer screens, and therefore, as a rule the more efficient ones, usually are the largest in diameter. Other factors shown in Table 1, which theoretically influence the quality of grading, such as speed and pitch of screen, apparently have very little practical effect. This is somewhat surprising, but may be explained by the probable influence of a factor which it was impossible to record, namely, the rate of feeding the stone into the screen. It is well known to all operators that the grading of the several products produced from a revolving screen will be influenced greatly by the rate of charging stone into the screen. Thus when loaded heavily a much larger proportion of fines will be found in the larger sizes than when only a small amount of stone is passing through. It is probable that the predominating influence of this factor has overshadowed the theoretical effect of speed and pitch of screen to such an extent that the small variations, usually found in the latter have no practical effect on the grading of the commercial sizes produced. Reference to table 1 will show that practically all revolving screens run with a speed of from 12 to 18 r. p. m., and are pitched with an inclination of from 1 to 1½ inches to the foot.

Another interesting point which may be noted in connection with plant design is the wide range in

If You Don't Come Across the Kaiser Will.
W. S. S.

diameter of screen perforations used by different operators in the same State, working the same type of rock and producing nominally the same commercial product. Thus as shown in Table 1, in six plants in New York working in limestone and producing "No. 3" stone, the perforations in the screens retaining this product ranged from 1¼ to 2½ inches, while those in the screen passing the product varied from 2¼ to 3 inches. Again, in Connecticut, as shown in Table 1, eight plants crushing trap rock for so-called 2-inch stone employed retaining screens with openings ranging from 1 to 1¾ inches and passing screens with openings ranging from 2¼ to 2½ inches. One other illustration will serve to call attention to a condition which apparently exists in all sections of the districts surveyed and for all types of stone. The five trap-rock plants in Massachusetts producing "peastone" as recorded in Table 1 used retaining screens with holes varying from ¼ to ½ inch and passing screens with holes ranging from ⅝ to ¾ inch. Notwithstanding these differences in size of holes, the resultant gradings do not vary as much as might be expected, indicating that slight variations in the diameters of the perforations in revolving screens do not cause corresponding variations in the grading of the products. Yet in the comparatively small field surveyed, screen preforations were found ranging from ⅛ to 3¾ inches, by steps differing by 1/16 inch. In all, 28 different sizes of screens were noted.

COMPARISON BETWEEN NOMINAL AND ACTUAL SIZES OF PRODUCTS.

For the purpose of determining the efficiency of stone screening operations as they are conducted at present, Table 4 was prepared. It shows the proportion of the total number of plants visited in each State whose products show various percentages passing a laboratory screen with the same perforations as the revolving plant screen on which the products are retained. These percentages are computed for each of the more commonly used grades of broken stone; the total number of plants in each case on which the computation is based also being given. In the several cases where there was no laboratory screen corresponding exactly to the plant retaining screen, the per cent of material passing the next smallest laboratory screen was used as the basis of the calculation. Such errors as are introduced in this way would, of course, tend to show a somewhat more efficient grading than actually existed.

Reference to the table brings out several interesting points. It will be noted that approximately 35 per cent of all the plants studied produce the ordinary commercial stone sizes with less than 5 per cent variation from the nominal sizes as called for by their plant installation. The average by States ranges from 44 per cent to 20 per cent. Likewise, a range of from 0 to 9 per cent of stone passing the respective retaining screens for similar commercial sizes will include about one-half of the plants with the single exception of one State where the percentage is only 30. In order to include products of a large majority of the plants it will be seen, however, that it is necessary to allow a tolerance of at least 15 per cent. Here the same general relations obtain, 75 per cent of the eight plants in one of the States showing less than 15 per cent variation from the nominal, whereas, only 45 per cent of the operations in another State are equally as efficient. The table shows then, in a general way, just what variations may be expected under present actual working conditions in the States visited, between the sizes which a revolving screen is supposed to produce ordinarily and the size it actually does produce.

The general averages throughout the table are reduced materially because of the very poor results obtained in a single State, where, for some reason, wide variations were noted constantly. For instance, for this State the table shows a general average of 62 per cent of all the plants visited having a variation of from 0 to 14 per cent of the stone passing the plant retaining screen, while in other States practically as high a percentage of the plants lie between 0 and 9 per cent variation. Therefore, a more accurate grading of stone may be expected from plants in these States. Bearing in mind the general operation of the smaller type of crushing plant where the whole product of the crusher falls first upon that screen section having the smaller perforations (exclusive of the dust jacket), it might be assumed that the grading of smaller sizes would be poorer than the larger. This appears to be substantiated in Table 4, where the general average for "peastone," for instance, shows only about 50 per cent of all plants with less than 15 per cent variation, whereas a corresponding average for the largest size produced shows about 70 per cent of the plants to be equally as efficient.

Further reference to Table 1 will show in a number of instances samples which contain a certain amount of material larger than the nominal perforations in the plant screen through which the sample was supposed to pass. Such a condition may be due to one of two causes, either to excessive wear in the screens or to poor bin or shute construction, which allows stone of a certain size to drop into the wrong bin. When it is considered, however, that the screening operation is progressive, the passing screen for one size becoming the retaining screen for the next larger size, and that the influence of all the other variables tends to retain a certain amount of stone on each screen which should have gone through, it would seem that the effect of wear may be neglected. From actual observations, moreover, it was found that holes in the ordinary plant screens rarely wear more than ¼ inch oversize, whereas a great many instances of faulty bin or chute

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construction were noted. The presence of oversize material, therefore, may reasonably be assumed to be due to this latter condition rather than to the fact that the screen perforations are slightly oversize.

COMPARISON OF NOMENCLATURE USED.

The column headed "Product known as," in Table I, contains the name given by operators to each of the 12 products. This information was recorded with the object of showing variations in nomenclature and the resultant confusion that may arise easily in purchasing stone for a special purpose from more than one producer. It brings out very clearly the need of a uniform system of designating commercial sizes of broken stone even if made applicable only within the State. To illustrate, consider the purchase of stone for constructing the bottom course of a water-bound macadam road in one of the New England States. Table 1 shows 17 plants in various parts of Massachusetts equipped to furnish the required stone. Of this total, one designates the size as "2-inch stone," four as "No. 1" stone, two as "No. 3," and two as "egg." Further than this, were a contractor to assume that "No. 3" referred to large stone and ordered accordingly from various plants in the State, it would be possible for him to receive stone chips from several plants. Again, many plants in the State are equipped to furnish stone for cement concrete construction, the stone being a combination of several products. Thus, one plant obtains the required stone by mixing "nut," "chestnut," and "peastone," while another obtains it by mixing "No. 2" and "No. 3."

In another section of Table I, which gives corresponding information with respect to Connecticut, it will be observed that a more uniform designation of stone exists. It is interesting to note, however, that although each of the several operators assigns the same name to stone used for similar purposes, the diameter of the perforations in the passing and retaining sections of the screens varies considerably. Thus, of three plants producing so-called "$1\frac{1}{4}$-inch stone," one obtains it by including all stone passing through $1\frac{3}{4}$-inch holes and retained on $1\frac{3}{16}$-inch holes; the second, by including stone passing through $1\frac{1}{2}$-inch holes and retained on $\frac{7}{8}$-inch holes; and the third, all stone passing $1\frac{1}{2}$-inch holes and retained on 1-inch holes. Again, of two plants producing almost identical stone sizes, the variation being $\frac{1}{16}$ inch in the size of hole of the retaining screen, one sells the product as "$1\frac{1}{4}$-inch stone" and the other as "$1\frac{1}{2}$-inch stone." Inasmuch as all of these products are used widely in the same type of construction and therefore are presumably each giving satisfaction, the question naturally arises, of what use are such slight variations in screen-size openings, especially as has been noted, when correspondingly fine variations in grading are not obtained?

By far the closest approach to a systematic designation of stone sizes is to be found in the products of the crushing plants of New York shown in Table I. Here, with but two exceptions, stone used for similar purposes is sold under the same designation by all operators. This uniformity undoubtedly is the result of the work of the State Highway Commission, which, in its specifications assigns a number to each of the stone sizes used in all work, and although variations appear in the actual diameters of screen perforations in the several plants producing "No. 3 stone" for instance, still the stone produced is intended to conform to the specification requirements.

The condition in one other State will suffice to illustrate the matter. An examination of Table I shows that to supply stone at all conformable to the State requirements, for the construction of the base course of a water-bound macadam road, four plants within Pennsylvania must mix "ballast" and "$1\frac{1}{2}$-inch stone," another "ballast" and "$1\frac{1}{4}$-inch stone," a third "No. 1" and "No. 2" stone, and a fourth "No. 5" and "No. 4" stone. Likewise, of seven plants equipped to furnish the State with stone for the construction of a cement concrete road, three would do so by combining their $1\frac{1}{2}$, 1, $\frac{3}{4}$, and $\frac{1}{2}$ inch stone, one by combining its $1\frac{1}{2}$, 1, and $\frac{3}{4}$ inch stone, one by making a combination of "No. 2," "No. 4," and "No. 5" stone, another by combining "No. 4," "No. 3," and "No. 2" stone, and still another by mixing "No. 3," "No. 2," and "No. 1 clean." In every case, at the time of visiting the plant these combinations were not made directly from the screens but in the cars at the time of loading. It must be remembered, of course, that the requirements of a local market other than that of the State, necessitated, in the majority of cases, the installation of intermediate screen sections and the assignment of names to the product from these sections for local sales only. Nevertheless, to obtain stone for any future road construction by the State within the market zone of any of the crushed stone operators listed in the tables, it still will be necessary for the engineer in charge to determine the meaning of the names given to the several sizes of stone produced before he can place orders intelligently

COMPARISON OF ACTUAL SIZES PRODUCED WITH SPECIFICATION REQUIREMENTS.

Having discussed the problems and discrepancies encountered in the production of broken stone aggregates, it is proposed here to call attention to the the products themselves, the actual sizes produced, as compared to the requirements of the correspond-

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ing State specifications. Tables 5, 6, and 7 contain the several requirements, in the section visited, for broken stone for use in water-bound macadam, bituminous macadam, and cement concrete construction, respectively, while Table 1 contains mechanical analyses of the products sold in these States. The methods used in specifying sizes vary considerably in the different States. In a number of cases, the specification is confined to a mere statement of the sizes required, without any reference to the basis for determining the size—thus, "the stone shall be from 1½ to 3 inches in size, largest dimensions." In other cases, requirements appear, such as, "shall consist of stones that will pass through a ring 2½ inches in diameter, but not through a ring 1¼ inches in diameter." In one case, the maximum and minimum diameters of holes are given with a proviso that as much as 15 per cent of stone, by laboratory test, may be smaller than the minimum diameter. In still another instance, the State specifies the diameter of the plant screens through which the product passes and on which it is retained, presumably accepting anything produced under these conditions. In Tables 5, 6, and 7 the several requirements may be assumed to be on the basis of the actual size of the stone, as determined by the laboratory test, unless otherwise noted in the tables.

A comparison of these specification requirements with the analyses of the various commercial products turned out in the corresponding States brings out some interesting facts. For instance, one of the New England States requires, as shown in line 1 of Table 5, a product which will pass a 1¼-inch screen and be retained on a ½-inch screen, with the further proviso that the stone be uniformly graded between these limits. Reference to Table 1 shows that not a single one of the 19 Massachusetts plants nominally turning out this product can meet the specifications literally, even if, as several have done, they use plant screens with perforations larger than the specified sizes. If, however, an upper and lower tolerance is inserted in this specification of, say, 5 per cent and 15 per cent to cover relatively unimportant variations from the specifications, 10 of the plants will be able to meet the requirement, the failure of the others being due to the use of screens with 1½-inch instead of 1¼-inch holes.

The same State, as shown in line 1, Table 6, requires for chip stone material passing a ½-inch but retained on a ¼-inch screen. Reference to Table 1 shows that not one of the 17 Massachusetts plants producing this stone can meet the requirement literally. The insertion of the tolerances mentioned above would admit 11 plants with respect to the lower limit, but still would exclude all 17 on the upper limit, principally on account of the general use of screens with ¾-inch or ⅝-inch holes, instead of ½-inch holes.

For the construction of the bottom course of a water-bound macadam road Connecticut specifies stone which shall range "from ¾ inch to 2 inches, longest diameter, mixed in the screens (not in the bins), the smaller sizes to predominate." An examination of Table 1 shows that none of the crushing plants visited in that State meet this requirement. They may approximate it by making a proportional mixture of the two larger products, but even then a large proportion of the stone will exceed 2 inches in size. Likewise, only three out of the eight plants tabulated show gradings at all conformable to the requirement of stone for the top course of a water-bound macadam road. In the case of a bituminous macadam road this State calls for cubical stone as nearly 1½ inches in diameter as possible for use in the penetration course, to be followed by "¾-inch stone," "½-inch stone," and "screenings free from dust." Reference to the table will show what the eight plants visited furnished for this purpose.

In Tables 5 and 6, line 7, are the requirements of New York for water-bound and bituminous concrete aggregates, while in Table 1 are the analyses of the products of a number of plants in that State turning out stone for use in building roads of these types. This specification provides that as much as 15 per cent of material in any of these products may be smaller than the lower limits specified. Reference to Table 1 shows that very few of the plants in the State meet the requirements, even on the basis of a 15 per cent tolerance. Almost all of these concerns appear to be turning out stone much smaller than required by the State. This is especially true of the larger sizes.

A study of the specification requirements of Pennsylvania will suffice to call attention to the obvious conclusion that, whatever the reason, but little coordination exists between the actual sizes of screened stone products and the requirements of the States in which they are to be used. Here an entirely different method of specifying stone sizes is employed, in that the diameters of the holes in the revolving screens on which and through which the product must pass is stated, with the additional requirement that it be graded uniformly between these limits. In other words, the actual equipment of a crushing plant determines whether or not an operator can furnish stone for State highway work. As a typical illustration, for the bottom course of a water-bound macadam road the highway department requires stone that will pass through a revolving screen having circular openings not less than 3 nor more than 3½ inches in diameter, and pass over a revolving screen having circular openings not less than 1¼ nor more than 1½ inches in diameter, and must be graded uniformly. Table 1 shows that six out of eight plants in Pennsylvania are equipped to furnish this stone, but only by combining the two largest commercial products. Of the six plants which can meet the letter of the specification, however, under this condition, the amount of material under 1¼ inches actually in the products themselves varies from 0 to 65 per cent, indicating quite a large possible range in grading under this method of specifying. Another requirement of this State specifies that "¾-inch stone" shall be "of such size as will pass over a revolving screen having circular openings not less than ⅝ inch or more than ¾ inch in diameter, and through a revolving screen having circular openings not larger than 1¼ inches in diameter." Table 1 shows five plants which meet the letter of the specification. Laboratory analyses of the products from these same five plants show materials ranging from 0 up to 85 per cent retained on a 1-inch laboratory screen, and from 0 to 58 per cent passing a ¾-inch laboratory screen. Such a condition well illustrates the uncertainty of attempting to control the grading of crushed stone products by simply specifying the plant screens over which and through which they shall pass.

GENERAL CONCLUSIONS.

Briefly summarized, the following points brought out by this discussion may be noted:

1. The length of a revolving screen influences the grading of the screen product to a marked degree.
2. Within the relatively narrow limits usually found in plant installation, pitch and speed of screen have no practical influence on grading, probably on account of other predominating factors, such as rate of feed of stone to the screen, which it is impossible, practically, to control.
3. The effect of oversize holes due to wear of the screen is practically negligible in view of the relatively large amount of stone usually held on a revolving screen which theoretically should have passed through it.
4. Small amounts of oversize stone, sometimes found in products screened through holes of certain nominal diameter, usually are due to faulty bin or chute construction, lack of repair, or other deficiencies in storing or handling the material.
5. The grading of the screened product can not be controlled with any degree of certainty by simply specifying the size of openings in the revolving screens over which and through which it shall pass.
6. It is neither practical nor necessary to specify that all material retained on and passing revolving screens of certain sizes shall lie between laboratory screens of the same size.
7. By the insertion of a reasonable tolerance, that is, one wide enough to cover the recognized inefficiency of the revolving screen, and yet close enough to insure sufficiently well graded materials, the laboratory screen may be used logically to control the grading of the plant product.
8. Inspection of the results so far obtained indicate that as much as 5 per cent material should be allowed larger than the size of revolving screen through which the product is supposed to pass, and as much as 15 per cent generally should be allowed smaller than the size of revolving screen upon which it is supposed to be retained. A consideration of the engineering features involved likewise indicates that these tolerances may be allowed ordinarily and still insure material graded sufficiently accurately for all practical purposes.

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APPLICATION OF RESULTS OBTAINED.

As stated, this survey was made primarily with the object of furnishing data which might be used as a basis for standardizing crushed stone sizes. It would, of course, be unfair to recommend specifically standard sizes for broken stone for use in the whole country on the basis of the data collected in the comparatively small district surveyed. It is believed, however, that enough information has been obtained to justify tentative recommendations which may be used as suggestions to both producers and users of crushed stone to indicate the possibilities along this line and so stimulate further discussion and criticism.

Any discussion of a system of crushed stone sizes will, of necessity, involve a consideration of the following points:

(1) The system must include each fundamental size which is in general use in recognized types of construction.

(2) The actual limits for each size chosen must be so adjusted as to conform to the best engineering practice for the type of construction involved.

(3) The sizes chosen must be so adjusted with respect to each other as to utilize, as far as possible, the entire product of a crushing plant, with the smallest percentage of tailings.

(4) The sizes chosen must be so adjusted with respect to each other that various combinations of them will conform to the best engineering practice in construction requiring mixed aggregates.

(5) The nature of the material to be crushed (i. e., its physical properties, hardness, toughness, etc.) should be considered in connection with the limits of size chosen.

(6) For convenience each size should be designated by an appropriate name.

(7) A method of specifying each size should be provided which will insure proper material being continually furnished and yet will be practical from the standpoint of economical plant operation.

(8) In addition to the above, another point applying especially to the adaptability of the system to portable, one-job, outfits is that the sizes must be so adjusted as to use as far as possible the entire product of the crusher on the work in hand.

Mention has been made that the unsystematic development of the broken stone road has resulted in the introduction of a great variety of stone sizes for comparatively few distinct types of construction, the variation often being of academic rather than practical significance. For instance, including only the States visited during this survey, a comparison of the current state specifications shows as many as 30 different sizes of stone specified for use in the construction of water-bound and bituminous macadam roads. Bearing in mind that these are all State specifications, and that in all probability many additional differences occur among the requirements of the various counties and municipalities, some idea may be obtained of the number of different sizes in use for these two types of road in this country at the present time. This does not include, of course, the several additional size requirements which have been drawn up from time to time to care for the construction of the various types of bituminous concrete pavements now used so widely. After making due allowances for justifiable variations in sizes due to local conditions, such as peculiarities in type of material, the fact remains that the multiplicity of sizes which exists is not only unnecessary and confusing, but also works a positive hardship upon the producer.

In consideration of the factors given above, there is suggested the general adoption of a series of sizes for broken stone aggregates, which it is believed will meet all essential requirements for the ordinary types of construction in use at the present time. Whole-number sizes have been chosen as far as possible, both on account of simplicity and ease of specifying an exact intermediate requirement when deemed advisable to do so. The permissible variations from the actual size limits here given have been inserted, so as to care for the unavoidable inefficiency of plant screening, as well as different degrees of inefficiency between several plants arising from one or more of the causes which have been noted. Thus it should be possible for an operator to use in his plant revolving screens with the same size circular openings as are used in the laboratory when the material is tested, and thereby produce material which, under ordinary circumstances, will comply with the specifications. In a number of cases there has also been inserted an intermediate size requirement with limits which it is felt are wide enough to permit of economical production and yet rigid enough to insure a product satisfactory for the type of construction in which it is to be used.

The sizes suggested, together with the proposed designation for each, the permissible variations allowed, and the form of specifying, are given below:[1]

No. 00. That portion of the product of the crusher, including the dust of fracture, which, when tested by means of laboratory screens, will meet the following requirements: Passing a ½-inch screen, 100 per cent; retained on a ¼-inch screen, not less than 20 per cent.

No. 0. That portion of the product of the crusher, including the dust of fracture, which, when tested by means of laboratory screens, will meet the following requirements: Passing a 1-inch screen, not less than 95 per cent; total passing a ¼-inch screen, 40 to 80 per cent.

No. ½. That portion of the product of the crusher, which, when tested by means of laboratory screens, will meet the following requirements: Passing a ½-inch screen, not less than 95 per cent; retained on a ½-inch screen, not less than 85 per cent.

No. 1. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 1-inch screen, not less than 95 per cent; total passing a ¾-inch screen, 25 to 75 per cent; retained on a ¼-inch screen, not less than 85 per cent.

No. 2. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 2-inch screen, not less than 95 per cent; total passing a 1½-inch screen, 25 to 75 per cent; retained on a 1-inch screen, not less than 85 per cent.

No. 3. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 3-inch screen, not less than 95 per cent; total passing a 2½-inch screen, 25 to 75 per cent; retained on a 2-inch screen, not less than 85 per cent.

No. 23. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 3-inch screen, not less than 95 per cent; total passing a 2-inch screen, 25 to 75 per cent; retained on a 1-inch screen, not less than 85 per cent.

No. 123. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 3-inch screen, not less than 95 per cent; total passing a 1½-inch screen, 25 to 75 per cent; retained on a ¼-inch screen, not less than 85 per cent.

No. 12. That portion of the product of the crusher which, when tested by means of laboratory screens, will meet the following requirements: Passing a 2-inch screen, not less than 95 per cent; total passing a 1-inch screen, 25 to 75 per cent; retained on a ¼-inch screen, not less than 85 per cent.

It will be seen that the only revolving screen equipment necessary for turning out any or all of these sizes are screen sections with circular openings 3, 2, 1, ½, and ¼ inches in diameter. Furthermore, in cases where No. 00 or No. ½ sizes are not desired, the ½-inch screen may be omitted, making it possible to manufacture everything by the use of a standard 3-section screen equipped with a ¼-inch dust jacket over the 1-inch section.

The sizes enumerated above may be employed in the construction of the following types of roads:

Type of construction.	Size or sizes.
Broken stone base	No. 3 or No. 23
Water-bound macadam wearing coarse	No. 2 or No. 12
Water-bound macadam screenings	No. 0 or No. 00
Bituminous macadam wearing coarse	No. 2
Bituminous macadam "chips"	No. 1
Bituminous concrete wearing course:	
One-size course aggregate	No. 1
Broken stone for graded course aggregate	No. 1
Broken stone for graded fine aggregate	No. 00
Bituminous concrete "chips"	No. ½
Sheet asphalt, binder course	No. 1
Cement concrete base	No. 123 or No. 12
Cement concrete wearing course	No. 12

It is felt that a careful study of the above will show that, although in some instances minor variations in size might be preferred, practically any of the types of roads here listed may be satisfactorily constructed with the sizes of aggregates proposed. The tables (1 to 7) referred to herein follow.

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[1] The form of specification used is that adopted by the First Conference of State Testing Engineer and Chemists and given in United States Department of Agriculture Bulletin No. 555.

TABLE I.

PENNSYLVANIA.

Plant No.	Type of rock.	Product known as—	Plant screens.								Mechanical analysis—Per cent between—									
					Dimensions.				Size of holes.											
			Pitch (inches per foot).	Speed, r. p. m.	Screen passing product.		Screen retaining product.													
					Length (feet).	Diameter (inches).	Length (feet).	Diameter (inches).	Screen passing product (inches).	Screen retaining product (inches).	Over 3 inches.	3–2½ inches.	2½–2 inches.	2–1½ inches.	1½–1¼ inches.	1¼–1 inches.	1–¾ inch.	¾–½ inch.	½–¼ inch.	Under ¼ inch.
1	Trap	Ballast	1½	12	4	72	5	72	3¼	1¾		45	55							
2	do	do	1½	20	9	60	18	60	3	2¼		66	34							
3	do	do	1½	20	15	60	8	60	3	2⅛		51	31	18						
4	do	do	1¼	17	8	60	8	60	3	2		44	43	13						
1	do	1½-inch stone	1½	12	5	72	5	72	1¾	1¼				26	44	27	3			
2	do	do	1½	20	9	60	8	48	2¼	1⅜				66	34					
3	do	1¼-inch stone	1½	20	8	60	8	60	1¾	1⅜					65	31	4			
4	do	1½-inch stone	1¼	17	12	84	12	60	2	1¼				58	33	7				
5	do	do	1¾	12	4	36	4	36	2	1¼				19	37	38	6			
1	do	1-inch stone	1½	12	5	72	5	72	1¼	⅞					11	38	43	8		
2	do	do	1½	20	9	48	9	48	1⅜	1					11	51	36	2		
3	do	do	1½	20	8	60	8	60	1¼	1					1	22	55	22		
5	do	do	1¾	12	4	36	4	36	1¼	1⅛						40	56	4		
1	do	¾-inch stone	1½	12	5	72	4	84	⅞	⅝						7	35	46	12	
2	do	do	1½	20	9	48	6	60	1	½							40	55	5	
3	do	do	1½	20	8	60	8	60	1	½							68	32		
4	do	do	1¼	17	10	60	10	60	1¼	½						28	60	12		
5	do	do	1¾	12	4	36	3	48	1⅛	¼						1	33	28	37	1
1	do	⅝-inch stone	1½	12	4	84	(2)		⅝	¼							14	65	21	
2	do	½-inch stone	1½	20	6	60	6	60	½	⅜								43	57	
3	do	do	1½	20	8	60	6	72	¾	⅜							3	37	58	2
4	do	do	1¼	17	10	60	6	72	¾	5/16								25	68	7
6	Limestone	No. 1	1½	15	4	36	4	36	3	2½		10	5	85						
7	do	No. 5	1½	12	4	42	4	42	3	2		15	41	44						
8	do	Ballast	1½	13	6	36	6	36	3	1½		38	50	12						
9	do	do	1½	18	6	48	6	48	2¾	1⅜		14	25	61						
6	do	No. 2	1½	15	4	36	4	36	2½	1½			15	37	24	21	3			
7	do	1-inch stone	1½	12	4	42	4	42	2	1½				11	25	21	33	10	1	
8	do	1¼-inch stone	1½	12	6	36	4	36	1½	¾				1	6	17	76			
9	do	¾-inch stone	1½	18	6	48	4	60	1½	⅝			24	38	31	9				
10	do	No. 3	1½	12	8	36	8	36	2½	1¾			44	45	10					
11	do	do	1½	15	6	40	4	51	2	1			7	69	19	5				
12	do	do	¾	15	9	36	9	36	1¾	1¼				40	30	23	7			
10	do	No. 2	1½	12	8	36	6	36	1¾	⅝				5	21	35	24	14		
11	do	do	1½	15	4	36	4	36	1	¾				9	30	47	15			
12	do	do	¾	15	9	36	4	48	1⅛	⅜						45	40	13	2	
6	do	No. 4	1½	12	4	36	4	36	1¼	¼						13	45	36	6	
11	do	No. 1 (clean)	1½	15	8	36	6	48	1	3/16							8	39	44	9
7	do	No 2	1½	12	6	42	3	51	1	¼							5	46	48	1
8	do	⅝-inch stone	1½	12	6	36	(3)		¾	½							1	26	65	9
9	do	⅝-inch (clean)	1½	18	4	30	4	30	½	¼							55	44	1	

NEW YORK.

13	Limestone	2½-inch stone	40°		(1)		(1)		3¼	2¼		31	57	12						
14	do	No. 4	1½	12	4	36	4	36	3¼	2¼	30	23	17	4	4	2				
15	do	do	⅝	18	4	36	6	48	3¾	3	33	39	28							
16	do	do	1½	14	17	72	15	84	3¼	2¼	25	44	30	1						
17	do	do	1⅛	13	6	60	6	60	3¼	2½		13	50	37						
13	do	1½-inch stone	40°		(1)		(1)		2¼	1⅜				14	17	40	28	1		
18	do	do	1	15	8	48	8	48	2⅛	1½				75	24	1				
19	do	No. 3	1½	16	4	36	4	36	2¼	1½			11	57	24	6	2			
14	do	do	1½	12	4	36	4	36	2¼	1½				42	41	15	2			
16	do	do	1½	14	15	84	20	61	2¼	1½			16	55	20	9				
20	do	do	1¼	19	10	46	10	46	2¼	1¼		8	40	44	7	1				
15	do	do	⅝	16	6	48	6	48	3	2½		24	36	35	3	2				
13	do	¾-inch stone	40°		(4)		(4)		1⅜	½						2	23	56	19	
18	do	do	1	15	8	48	6	48	1⅛	⅜						5	23	26	41	5
19	do	No. 2	1½	16	4	36	4	36	1½	1¼				5	54	32	8	1		
14	do	do	1½	12	4	36	4	36	1½	1¼					3	26	50	20	1	
21	do	do	1¾	14	4	60	4	60	1¼	¾				5	14	33	41	7		
16	do	do	1½	14	20	61	15	84	1½	⅝					3	7	36	38	16	
20	do	do	1¼	19	10	46	10	46	1¼	¾				24	19	33	20	4		
15	do	do	⅝	16	6	48	6	48	2½	1¼					23	39	32	6		
17	do	do	1⅛	12	6	60	8	42	1¼	⅝					4	9	48	34	5	
18	do	⅜-inch stone	1	15	4	48	12	48	⅜	¼									78	22
19	do	No. 1	1½	16	4	36	4	36	1¼	7/16					3	15	45	23	11	3
21	do	do	1¾	14	4	60	3	72	¾	7/16							2	32	65	1
16	do	do	1½	14	15	61	12	72	⅝	⅜								5	51	44
20	do	do	1½	13	8	48	8	48	⅝	¼								12	79	9
15	do	do	⅝	16	6	48	5	60	1¼	⅞								22	60	18
17	do	do	1⅛	13	8	42	8	42	⅝	¼								22	74	4
19	do	Pea	1½	16	4	36	3	48	5/16	3/16								9	58	33

NEW JERSEY.

24	Granite	2½-inch stone	¾	10	4	42	4	42	3	2		13	65	22						
24	do	1½-inch stone	¾	10	4	42	6	42	2	1¼			16	79	5					
25	do	do	1½	12	4	36	4	36	2	1½			9	67	18	6				
25	do	1-inch stone	1½	12	4	36	4	36	1½	1					39	51	10			
24	do	¾-inch stone	¾	10	6	42	4	12	1¼	⅜					6	65	27	2		
25	do	do	1½	12	4	36	4	36	1	¾						10	79	31		

[1] Square mesh.
[2] Pulsating screen, 4′x 10′.
[3] Pulsating screen, 3′x6′.
[4] Gravity screen, 8 feet by 24 inches.

TABLE I—Continued.

Plant No.	Type of rock	Product known as	Plant screens.								Mechanical analysis—Per cent between—									
					Dimensions.				Size of holes.											
					Screen passing product.		Screen retaining product.													
			Pitch (inches per foot).	Speed, r. p. m.	Length (feet).	Diameter (inches).	Length (feet).	Diameter (inches).	Screen passing product (inches).	Screen retaining product (inches).	Over 3 inches.	3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1¼ inches.	1¼-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.	Under ¼ inch.
MARYLAND.																				
26	Granite	Ballast	1½	15	20	60	10	60	3	1½		36	53	11						
27	do.	2½-inch stone	1½	12	5	48	5	48	2	1¼			5	47	33	10	5			
26	do.	1½-inch stone	1½	15	10	60	10	60	1½	1					11	52	35	2		
26	do.	1-inch stone	1⅛	15	10	60	8	72	1	¾							31	56	13	
27	do.	Chips	1½	12	5	48	5	48	1	⅜						6	26	39	27	2
NEW YORK.																				
22	Trap	2½-inch stone	1	15	20	60	20	60	3⅛	1⅞		44	40	16						
22	do.	1½-inch stone	1	15	14	60	10	60	2¼	1⅛				46	20	20	11	3		
22	do.	¾-inch stone	1	15	10	60	8	72	1⅛	5/16						9	43	31	16	1
23	Granite	No. 3	1¼	11	10	84	20	84	2¾	1½		5	21	55	12	7				
23	do.	No. 2	1¼	11	20	84	10	84	1½	¾					10	22	54	14		
23	do.	No. 1	1¼	11	10	84	12	96	¾	5/16							1	11	66	22
NEW JERSEY.																				
29	Trap	2½-inch stone	1	12	10	42	6	47	2½	1⅞		39	54	7						
30	do.	do.	1	14	10	48	15	48	3	2¼		70	30							
31	do.	Ballast	1½	15	8	51	8	51	3	2	34	55	11							
33	do.	1-inch stone	1¼	12	4	48	4	48	1⅞	1⅛					15	31	42	11	1	
33	do.	1½-inch stone	1½	15	8	51	7	51	2¼	1½				49	47	1				
28	do.	do.	1½	12	4	48	4	48	2⅛	1⅛			5	95						
29	do.	do.	1	12	4	42	8	48	1⅞	1¼				33	34	26	7			
30	do.	do.	1	14	6	48	6	48	2¼	1¼			32	65	3					
31	do.	do.	1½	15	8	51	8	51	2	1¼				76	24					
32	do.	do.	1½	12	4	48	4	48	1⅞	1⅛				42	35	13	10			
33	do.	¾-inch stone	1⅛	15	8	51	8	51	1¼	¾						7	54	34	5	
28	do.	do.	1½	12	4	48	12	36	1⅛	¾					9	83	8			
30	do.	do.	1	14	4 6	60 48	4 6	60 48	1¼	¾						11	78	11		
31	do.	do.	1½	15	6 6	51 51	4 4	60 60	1¼	⅝					10	40	47	3		
33	do.	½-inch stone	1⅛	15	6	51	6	51	¾	½								26	64	10
28	do.	do.	1½	12	4	48	3	60	⅝	¼									66	34
28	do.	⅜-inch stone	1½	12	12	36	4	48	¾	½								27	66	7
29	do.	½-inch stone	1	12	6	42	4	56	¾	¼							5	29	44	23
MASSACHUSETTS.																				
34	Trap	Egg	1	13	6	48	6	48	2½	1½			55	38	5	2				
35	do.	do.	1¼	18	4	40	4	40	2½	1½			39	49	12					
36	do.	2-inch stone	1	15	4	48	12	48	2¼	1⅝			25	61	14					
37	do.	No. 1	1	18	3	36	1	36	2½	1½			39	40	13	6	2			
38	do.	2-inch or No. 3	1	18	4	32	4	32	2½	1½			28	68	4					
34	do.	Nut	1	13	6	48	12	48	1½	1					8	53	31	8		
35	do.	do.	1¼	18	4	40	4	40	1½	1				11	23	53	11	2		
36	do.	1½-inch stone	1	15	12	48	6	70	1⅝	1⅛				15	51	26	8			
34	do.	Chestnut	1	13	12	48	4	60	1	¾					4	15	64	17		
35	do.	do.	1¼	18	4	40	3½	52	1	⅝							62	33	5	
36	do.	¾-inch stone	[1] 1	22-15	6	70	6	60	1⅛	⅝						4	57	36	3	
37	do.	No. 2	1	18	1	36	2	36	1½	¾						9	37	48	6	
38	do.	1½ inch or No. 2	1	18	4	32	4	32	1½	⅝					16	49	31	4	3	
34	do.	Pea	1	13	4	60	2	60	¾	½								37	59	4
35	do.	do.	1¼	18	3½	52	3	60	⅝	¼								15	68	17
36	do.	do.	¾	22	6	60	6	60	⅝	¼								20	78	2
37	do.	do.	1	18	2	36	3	36	¾	¼								21	55	17
38	do.	do.	1	18	4	32	3	40	⅝	⅜								19	75	6
39	Sandstone	2½-inch stone	1¼				2	30		2			49	44	5	2				
39	do.	2-inch stone	1¼		2	30	4	30	2	1¼				59	36	5	1			
40	do.	do.	1	15	3	36	3	36	2½	1¼			5	50	27	15	2	1		
39	do.	1-inch stone	1¼		4	30	4	30	1¼	¾						23	56	20	1	
40	do.	do.	1	15	3	36	3	36	1¼	⅝						9	34	49	8	
39	do.	½-inch stone	1¼		4	30	3	42	¾	⅜						1	1	57	39	2
40	do.	do.	1	15	3	36	4	36	⅝	⅜								18	75	7
41	Granite	2-inch stone	1	11	6	32	3	32	2½	1¼			24	58	14	4				
42	do.	No. 1	1½	18	5	30	5	30	2	1			16	36	26	19	3			
43	do.	2-inch stone	1½	30	5	24	5	24	2½	1½			5	58	32	4	1			
44	do.	No. 1	1½		4	30	4	30	2½	1½			18	50	21	10	1			
45	do.	2½-inch stone	1	15			3	30		1½			47	33	15	1	4			
46	do.	No. 1	1	12	6	48	6	48	2¼	1½			42	56	2					
47	do.	2-inch stone	1¼	11	6	48	6	48	2¾	1¾			45	40	5					
41	do.	1-inch stone	1	11	3	32	6	30	1¼	[2] ½						10	46	39	5	
42	do.	No. 2	1½	18	5	30	5	30	1	⅝						5	36	49	10	
43	do.	1-inch stone	1½	30	5	24	4	36	1½	¼					36	44	17	2	1	
44	do.	No. 2	1½		4	30	4	30	1½	¾					19	44	27	8	2	
45	do.	1½-inch stone	1	15	3	30	2	42	1½	¼					25	38	19	11	4	3
46	do.	No. 2	1	12	6	48	6	48	1½	¾				9	37	28	23	3		
47	do.	1½-inch stone	1¼	11	6	48	6	48	1¾	1⅜				49	41	10				
47	do.	1-inch stone	1¼	11	6	48	5	60	1⅜	⅝					5	53	31	10	1	
41	do.	½-inch stone	1	11	6	30	3	32	½	⅜							2	11	81	9
42	do.	Pea	1½	18	5	30	4	42	⅝	[2] ¼								16	80	4
44	do.	No. 3	1½		4	30	([2])		¾	¼								6	73	21

[1] Square holes.

[2] Grizzly.

TABLE 1—Continued.

MASSACHUSETTS—continued.

Plant No.	Type of rock.	Product known as—	Plant screens.								Mechanical analysis -Per cent betwee									
					Dimensions.				Size of holes.											
					Screen passing product.		Screen retaining product.													
			Pitch (inches per foot).	Speed, r. p. m.	Length (feet).	Diameter (inches).	Length (feet).	Diameter (inches).	Screen passing product (inches).	Screen retaining product (inches).	Over 3 inches.	3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1¼ inches.	1¼-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.	Under ¼ inch.
46	Granite	No. 3	1	12	6	48	5	60	¾	½								44	56	
47	do	Pea	1¼	11	5	60	4	72	⅝	¼								16	58	26
48	Rhyolite	2-inch stone	1	15	8	36	6	36	2¼	1½			48	49	2	1				
49	do	do	1	18	5-5	38-32	5-5	38-32	2½	1⅜			48	42	6	4				
50	do	do	1½	10	6	48	6	48	2½	1½			50	39	7	3	1			
51	do	do	1	......	3	28	3	28	2½	1½			16	61	18	5				
52	do	2-inch or No. 3	½	13	4	36	4	36	2¼	1¾			21	70	6	3				
48	do	1-inch stone	1	15	6	36	6	36	1½	¾				3	8	19	47	21	2	
49	do	do	1	18	5	38-32	5	38-32	1¼	¾				2	25	33	33	7		
50	do	do	1½	10	6	48	6	48	1½	¾				5	27	39	27	2		
51	do	do	1	......	3	28	4	28	1½	¾					16	40	36	8		
52	do	1½-inch stone	½	13	4	36	6	36	1¼	¾				15	44	16	21	4		
48	do	½-inch stone	1	15	6	36	5	48	¾	⅜							3	17	56	2
49	do	do	1	18	5	38-32	(1)		¾	¼								40	56	
50	do	do	1½	10	6	48	5	60	¾	⅜						2	22	37	37	
51	do	Pea	1	......	4	28	(1)		¾	¼								29	54	1
52	do	do	½	13	6	36	2	48	¾	⅜								62	37	

CONNECTICUT.

Plant No.	Type of rock.	Product known as—	Pitch (inches per foot).	Speed, r. p. m.	Screen passing product: Length (feet).	Screen passing product: Diameter (inches).	Screen retaining product: Length (feet).	Screen retaining product: Diameter (inches).	Size of holes: Screen passing product (inches).	Size of holes: Screen retaining product (inches).	Over 3 inches.	3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1¼ inches.	1¼-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.	Under ¼ inch.
53	Trap	2-inch stone	1½	13	15	60	15	48	2½	1¾			56	44						
54	do	do	1	12	8	48	8	48	2¼	1¼			14	53	21	6	3	3		
55	do	do	1½	30	32	72	24	48	2½	1½			41	57	1	1				
56	do	do	1½	18	5	48	10	48	2½	1½			40	60						
57	do	do	1½	......	10	36	8	48	2¼	1			5	58	13	12	10	2		
58	do	do	1½	18	5	38	10	38	2¼	1½			26	51	21	2				
59	do	do	1	20	5	48	5	48	2¼	1¾			56	40	4					
60	do	do	1¼	15	6	36	6	36	2½	1⅜			4	69	24	3				
53	do	1¼-inch stone	1½	13	15	48	12	60	1¾	1 3/16				57	37	6				
54	do	1-inch stone	1	12	8	48	8	60	1¼	⅞					11	51	30	7	1	
55	do	1¼-inch stone	1½	30	20	48	16	60	1½	⅞					17	44	32	6	1	
56	do	1-inch stone	1½	18	10	48	5	60	1½	1⅛					70	29	1			
58	do	1¼-inch stone	1½	19	10	38	8	50	1½	1					18	50	30	2		
60	do	1½-inch stone	1	20	5	48	5	48	1¾	1¼			3	52	34	10	1			
53	do	¾-inch stone	1½	13	18	48	8	60	1	⅝							12	77	11	
54	do	do	1	12	8	60	12	30	⅞	⅝							24	63	13	
55	do	do	1½	30	12	60	8	48	⅞	⅝						1	57	36	6	
56	do	do	1½	18	5	60	12	48	1⅛	⅝						14	84	1	1	
57	do	do	......	......	8	48	(2)		1	½							20	56	23	1
58	do	do	1½	18	8	50	12	36	1	⅝							29	63	8	
59	do	do	1½	18	6	48	6	48	¾	⅝							19	39	39	3
60	do	do	1¼	15	6	36	6	48	1	⅝						7	49	36	8	
53	do	½-inch stone	1½	13	18	48	15	60	⅝	⅜								18	78	4
54	do	do	1	12	12	30	8	42	⅝	¼								9	74	17
55	do	do	1½	30	8	48	7	60	⅝	⅛								43	54	3
56	do	do	1½	18	12	48	8	60	⅝	⅛							1	6	54	39
57	do	do	1½	......	(2)	......	(2)	......	½	⅜								28	71	1
58	do	do	1½	18	12	36	8	50	⅝	¼							2	14	75	9
59	do	do	1	20	6	48	6	48	⅝	⅜								1	47	52
60	do	do	1¼	15	7	48	(2)	......	⅝	⅛								1	35	64

MAINE, NEW HAMPSHIRE, AND VERMONT.

Plant No.	Type of rock.	Product known as—	Pitch (inches per foot).	Speed, r. p. m.	Screen passing product: Length (feet).	Screen passing product: Diameter (inches).	Screen retaining product: Length (feet).	Screen retaining product: Diameter (inches).	Size of holes: Screen passing product (inches).	Size of holes: Screen retaining product (inches).	Over 3 inches.	3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1¼ inches.	1¼-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.	Under ¼ inch.
61	Granite	No. 3	1½	24	3	30	3	30	2½	2		10	27	34	20	8	1			
62	do	Tailings	1	22	......	......	3	32	......	2		66	30	4						
63	do	No. 4	1	14	3	32	4	32	2½	1¼		6	45	36	13					
64	do	No. 3	1	16	3	42	8	42	3	2		27	37	36						
65	do	No. 1	1½	18	4	36	4	42	2	1½			61	32	7					
61	do	No. 2	1½	24	3	30	4	30	2	1				24	51	25				
62	do	do	1	22	3	32	3	32	2	1¼					44	33	16	7		
63	do	No. 3	1	14	4	32	4	32	1¼	¾				19	18	34	26	3		
66	do	do	1	13	4	42	4	42	1½	⅝				5	42	33	18	2		
64	do	No. 2	1	16	8	42	4	42	2	1			8	52	17	15	8			
65	do	do	1½	18	4	42	4	42	1½	¾				2	19	38	35	6		
61	do	No. 1	1½	24	4	30	3	42	1	⅜						5	19	37	37	2
62	do	do	1	22	3	32	3	32	1¼	½						2	49	42	7	
67	do	No. 3	1	18	2½	36	2½	36	1	½							43	45	12	
61	do	Pea	1½	24	3	42	(3)		⅜	3/16								3	51	46
63	do	No. 2	1	14	4	32	4	32	¾	¼							26	54	19	1
66	do	do	1	14	4	42	4	42	⅝	⅛								14	74	12
67	do	do	1	18	2½	36	2½	36	½	¼									83	17
64	do	No. 1	1	16	4	42	(3)	......	1	¼							19	31	31	19
65	do	Pea	1½	18	4	42	3	54	¼	¼							7	70	22	1

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[1] Gravity screens.

[2] Pulsating, 6 by 6 feet.

[3] Gravity screens, 3 by 9 feet.

TABLE 2.

POWER REQUIREMENT AND OUTPUT OF CRUSHING PLANTS.

Plant No.	Type of material.	Total horse-power.	Output per day.	Plant No.	Type of material.	Total horse-power.	Output per day.
			Tons.				*Tons.*
1	Trap	175	300	35	Trap	100	500
2	do	700	2,500	36	do	130	600
3	do	400	1,000	37	do	25	150
4	do	420	1,000	38	do	45	90
5	do	80	400	39	Sandstone	25	100
6	Limestone	200	500	40	do	50	100
7	Sandstone	240	300	41	Syenite	40	100
8	do	150	450	42	Granite	40	150
9	Limestone	400	1,000	43	do	70	100
10	do	100	200	44	do	35	90
11	do	90	600	45	do	35	100
12	do	50	100	46	do	175	500
13	do	2,000	5,500	47	Slate	100	250
14	do	50	200	48	Rhyolite	75	200
15	do	350	1,000	49	do	85	250
16	do	400	3,000	50	do	125	400
17	do	310	1,000	51	do	60	150
18	do	250	900	52	do	40	90
19	do	35	85	53	Trap	610	5,000
20	do	550	3,000	54	do	275	900
21	do	175	400	55	do	350	1,000
22	Trap	2,000	8,000	56	do	100	400
23	Gneiss	1,200	3,000	57	do	150	400
24	Trap	50	250	58	do	150	400
25	Granite	100	100	59	do	340	900
26	do	1,000	2,500	60	do	75	200
27	do	125	1,000	61	Granite	30	100
28	Trap	300	500	62	do	40	100
29	do	50	225	63	do	35	150
30	do	450	900	64	do	60	150
31	do	385	1,200	65	Sandstone	75	200
32	do	75	150	66	Granite	85	200
33	do	300	1,500	67	do	75	50
34	do	225	300				

TABLE 3.

EFFECT OF LENGTH OF SECTION ON EFFICIENCY OF PLANT SCREENING.

Length of plant screen retaining product.	Per cent of total plants, samples from which show less than 15 per cent passing a laboratory screen with same size holes as corresponding plant screen.					
	2-inch stone.		¾-inch stone.		Pea stone.	
	Number plants sampled.	Per cent.	Number plants sampled.	Per cent.	Number plants sampled.	Per cent.
Feet.						
1	1	0				
2			1		1	
3	5	40	1	100	10	50
4	11	45	13	60	9	55
5	5	80	2	100	3	35
6	10	80	7	70	6	50
8	7	85	8	65	4	100
10	3	70	3	100		
12	1	100	4	100	2	50
15	2	100			1	100
18	1	100				
20	3	100				

TABLE 4.

EFFICIENCY OF PLANT SCREENING.

Grouped by States and sizes.

Number of plants.	Approximate size of product.	Proportion of plants showing the following variations from nominal size.			
		Less than 5 per cent.	Less than 10 per cent.	Less than 15 per cent.	Over 15 per cent.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
18	2½ inches to 1½ inches	22	44	66	34
16	1½ inches to ¾ inch	37	62	75	25
17	¾ inch to ½ inch	35	47	47	53
	Average	29	51	63	37
8	2½ inches to 1½ inches	50	50	75	25
6	1½ inches to 1 inch	33	66	83	17
8	1 inch to ½ inch	13	51	76	24
8	½ inch to ¼ inch	50	63	63	37
	Average	36	56	75	25
8	3 inches to 2 inches	63	63	75	25
10	2 inches to 1¼ inches	20	40	50	50
8	1¼ inches to ¾ inch	38	50	75	25
8	¾ inch to ¼ inch	63	75	75	25
	Average	44	56	68	32

TABLE 4—Continued.

EFFICIENCY OF PLANT SCREENING—continued.

Grouped by States and sizes—Continued.

Number of plants.	Approximate size of product.	Proportion of plants showing the following variations from nominal size.			
		Less than 5 per cent.	Less than 10 per cent.	Less than 15 per cent.	Over 15 per cent.
5	3½ inches to 2½ inches	0	0	40	60
10	2½ inches to 1½ inches	20	30	30	70
9	1½ inches to ¾ inch	11	33	55	45
9	¾ inch to ¼ inch	33	44	55	45
	Average	20	30	45	55
4	3 inches to 2 inches	75	75	75	25
9	2 inches to 1¼ inches	44	55	66	34
6	1¼ inches to ¾ inch	50	50	67	33
4	¾ inch to ¼ inch	0	0	0	100
	Average	43	59	56	44
	General average	34	49	61	39

TABLE 5.

WATER-BOUND MACADAM.

State requirements for size.

State.	Bottom course.		Top course.		Screenings.	
	From—	To—	From—	To—	From—	To—
Massachusetts	2½	1¼	1¼	½	½	Dust.
Connecticut	2	¾	2	1	½	Dust.
Maine	2¾	1¾	1¾	¾	¾	Dust.
New Hampshire	2½	1¼	1	½	½	Dust.
Vermont	2½	1½	1½	½	½	Dust.
Rhode Island	3	1	1	Dust.		
New York	3¾	[1] 2¾ or 1½	2¾	[1] 1½	⅝	Dust.
Pennsylvania	[2] 3½ or 3	[2] 1½ or 1¼	[2] 3	[2] 1½ or 1¼	[2] ¾ or ⅝	Dust.[3]
New Jersey	3½	2¼	2¼	1½	⅝	Dust.
Maryland	3	1	2	1	1	Dust.

[1] As much as 15 per cent by laboratory test allowed smaller than the lower limit in each case.

[2] Materials must pass over and through revolving screens of the sizes indicated.

[3] If screenings of ¾-inch maximum size are used, they shall contain not less than 15 per cent nor more than 12 per cent, by weight, of dust passing No. 100 laboratory sieve, and not less than 12 per cent, by weight, of particles passing No. 20 and retained on No. 100 laboratory sieve. Screenings passing ⅝ inch shall vary between limits proportionately higher than those specified above.

TABLE 6.

BITUMINOUS MACADAM.

State requirements for size.

State.	First course.		Second course.		Seal.	
	From—	To—	From—	To—	From—	To—
Massachusetts	2½	½	½	¼	½	¼
Connecticut	2½	¼	¾	½		
Maine	3¼	2¼	2¼	1	1	¼
New Hampshire	3	1¼	1	½	½	¼
New York	2¾	[1] 1½	1½	[1] ⅝	⅝	[1] ⅜
Pennsylvania	[2] 3	[2] 1½ or 1¼	[2] 1¼	[2] ¾ or ⅝	[2] ¾ or ⅝	[2] ¼
New Jersey	2¼	1¼	1¼	⅝	⅝	¼
Maryland	3	1	1	Dust.	1	½

[1] As much as 15 per cent by laboratory test allowed smaller than the lower limit in each case.

[2] Materials must pass over and through revolving screens of the sizes indicated

TABLE 7.

CEMENT CONCRETE WEARING COURSE.

State requirements for size.

State.	From—	To—
Massachusetts	1½	¼
Connecticut	1¼	½
Vermont	1½	¼
New York	2¾	[1] ⅜
Pennsylvania	2 or 1½	[2] ¼
Maryland	2½	¼

[1] As much as 15 per cent by laboratory test allowed smaller than ⅜ inch.

[2] Materials must pass over and through revolving screens of the sizes indicated. Not more than 5 per cent by laboratory test to pass a ¼-inch round opening.

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING ROAD PUBLICATIONS.

NOTE.—(Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free).

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

BULLETINS.

(In applying for these bulletins the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28").

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and Classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53").

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.

*Department supply exhausted.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given, as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars (1911.) 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETINS.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239".)

F. B. *239. The Corrosion of Fence Wire. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c.
*461. The Use of Concrete on the Farm. 5c.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given, as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables upon the Penetration Test for asphalts and asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

*Department supply exhausted.

FARMERS DO UTMOST, BUT CITY MEN MUST HELP.

With favorable weather and with a supplement of man power from the towns and cities to help in farm tasks of particular strain, especially in harvesting, there is every reason to anticipate increased yields of farm products in the United States this year over the record production last year, but the promise for the future does not in the least warrant relaxed efforts both for greater production and for greater conservation. The increases should be reassuring to consumers and a matter of encouragement to farmers that they can again overcome difficulties. There is a continuing need for large supplies of food and feed products, not only for our own population but for the Allies in Europe who will depend more and more on this country.

The farmers last year responded generously to the patriotic appeal of the President, the Department of Agriculture, the State Colleges of Agriculture, and other public agencies, by planting and harvesting the largest acreage in crops on record in this country. Since July of last year the Department of Agriculture, in cooperation with the Agricultural Colleges and other State and local organizations, has labored unceasingly to maintain, and if possible to increase in 1918, the record acreages of 1917, with necessary adjustments especially to provide for larger production of wheat and other bread grains which are most needed.

The results of the Department's efforts are now becoming apparent. The indicated increased acreage in food crops this year over the record crop of 1917 is gratifying. An increase over the record for peace times would have been striking in view of all the difficulties. The vigorous efforts of the farmers evidence their patriotic determination to help win the war. Reports indicate that in order to plant larger acreages with less help than ever before, farmers are working from early dawn until black darkness, utilizing to the fullest capacity all their man power, family power, horse power, and machinery, and setting an example of extraordinary exertion and efficiency which might well be followed in other essential industries. The work of the farmers and of the agricultural agencies is not spectacular and does not catch the public eye, but it is nevertheless unceasing and effective and is as vitally important as any other service rendered in the Nation in this emergency. American farmers are entitled to and should receive the fullest credit, appreciation, and recognition. They and their families are doing and will continue to do their utmost to help win the war for human freedom against the outlaws of the military autocracy of Europe which threatens all that is held most dear and sacred by civilized peoples.

Farmers have done and will continue to do their part. They have planted generously. They will need the assistance in cultivation and harvesting of many additional laborers. The critical factors in crop production after planting will be weather and labor. Weather is beyond human control, but the necessary labor for cultivating and havesting the food crops planted by the farmers of this country must be supplied when and where most needed.

The Departments of Agriculture and Labor are cooperating and are taking every step possible to help the farmers secure labor. It now devolves upon the cities and towns to lend assistance. This duty exists in peace times because the urban communities are vitally dependent upon the back country for their very existence; some owe their very being to the surrounding rural districts. In this emergency they must labor with other agencies to see that the crops are cultivated and harvested. I trust that the thoughtful people of the towns and cities will realize that the farmers can not work miracles, and that upon the cities rests the responsibility of furnishing the necessary supplement of man power.

D. F. HOUSTON,

Secretary of Agriculture.

1. 3

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 3 WASHINGTON, D. C. JULY, 1918

A SNOW-CLAD FORTRESS OF THE RANGE. MOUNT HOPE, INDEPENDENCE PASS, COLO.

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both houses of Congress. Others desiring to obtain PUBLIC ROADS can do so by sending 15 cents for each number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

It is the desire of the Bureau of Public Roads and the Government Printing Office to issue PUBLIC ROADS regularly on the 20th of each month, but it must be borne in mind by the readers that in these war times the tremendous volume of emergency printing takes precedence in the Printing Office and due allowance be made for delays.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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1918

BUREAU OF PUBLIC ROADS.

Logan Waller Page . . . . Director.
P. St. J. Wilson . . . Chief Engineer.
J. E. Pennybacker . Chief of Management.
Jules L. Goldberg . . . . . . Editor.

MAINTENANCE OF OUR HIGHWAYS

THAT improved roads constitute liabilities as well as assets in a community, is a point of view long disregarded, but likely in these days to be impressed emphatically upon the administrative officials of many States and counties. It is hardly open to denial that in many places there has been an unwillingness to face the fact that an improved road imposes a more or less definite annual charge on the community's resources. Now, when shortage of materials and transportation facilities and the high cost of labor and equipment are added to the urgent necessity for maintenance, it is gratifying to note the marked agreement among representatives of the biggest highway organizations that the outstanding and continuing liabilities must be honestly met before any more new work shall be undertaken.

The current existing conditions come at a time when in many sections the increase of truck traffic is causing much more rapid wear than many road organizations are fully prepared to meet from current funds. Unexpectedly the annual or periodical liability attached to some improved roads has increased beyond all calculations, and the matter of adequate maintenance is receiving most serious consideration in many quarters for the first time. The huge public investment in road construction if lost even in small part will amount to an imposing loss of public values.

TIME TO CONSERVE EVERY RESOURCE.

It is a proper time to turn attention to every new idea and device for saving labor. There should be a careful conservation of repair materials. The available annual road funds in counties, road districts, and States should be more carefully distributed, so that expensive, heavily traveled roads may certainly receive the attention they need in the twelfth month of the fiscal year as well as in the first. Where arrangements can legally be made to do so, it is the best possible time to put convicts in quarries and gravel pits to get out repair materials. Road equipment ordinarily left exposed to the weather to suffer thereby undue depreciation should be repaired, painted, and kept in the highest condition of service possible.

Most of all, the one thing that has been commonly neglected should now be the first consideration. Many officials never have attempted to foresee the season's demands with anything like the exactness necessary to prepare adequately for proposed work. Some State departments can not foresee in the winter, in time to make suitable surveys, the construction they are expected to execute in the following season. This may be the result of State laws, or it may result from a number of causes, but it is imperative now that the future needs of maintenance be foreseen and provided for to a considerable degree or highway work will suffer. The allocation of road bitumens, the distribution of orders for cement, the difficulties in securing dimensioned lumber, and the ever-present doubt and delays attendant on car shortage, make it imperative that the essential requirements of the repair season be anticipated with as great exactness as possible, if the work of repair and maintenance is to have any great degree of effectiveness.

GREATEST GOOD AT LEAST EXPENSE.

Eventually much good may come from the present situation. If a more careful consideration of all these details lead to a general introduction for all time of methods necessary now to secure the greatest good result with the least loss and expense, if, for instance, local road budgets for maintenance can be started, the ultimate results will be of the greatest advantage to the public and to all road administrators and officials.

How the State highway authorities are meeting the present situation and solving the problems that confront them is set forth in the appended articles.

Constant Effort by a Paid Force Advocated For Results In Colorado

By T. J. EHRHART, Commissioner State Highway Department.

Road maintenance is one of the most important problems that confronted us in our road-building program. To better understand what it involves it may be well to consider the extent and value of the property dealt with.

There are to-day some 40,067 miles of public roads in Colorado. The rights of way average 60 feet in width or 71.5 acres to the mile, making a total of 288,468.40 acres. At a conservative valuation of $10 per acre, these rights of way are worth $2,884,684.

The permanent improvements on these roads, including bridges, culverts, grading, and surfacing are, without doubt, worth $25,000,000. I believe the people of Colorado have contributed not less than $35,000,000 for road improvement and maintenance during the history of the State.

To fully maintain these roads in their present condition, allowing no depreciation, will cost at least 5 per cent annually of the total amount invested or considerably more than $1,000,000.

The question is, would it be a good business proposition for the counties of this State, owning a property so valuable, to pursue the same course that any big business concern does when it annually sets aside a fixed amount for maintenance cost, and another amount to cover cost of depreciation in values? In this case with proper maintenance there is no depreciation. The answer is, without a dissenting voice from any source, "certainly we should take care of this maintenance."

PROBLEM MORE COMPLICATED DAILY.

Because of a limited State fund, much of the road improvement and maintenance in Colorado has devolved upon county authorities, and they in turn, lacking a comprehensive system, have met their road problems in divers ways.

Some of them, for example, have adopted a system of dragging which keeps their roads generally in very good condition, but others, lacking an organization, simply send out men here and there when roads become impassable or very nearly so.

Frequently lack of funds enters into the question, and with the increasing scarcity of labor and higher cost of materials the problem is daily becoming more complicated.

My own plan for betterment of roads and their maintenance follows that generally adopted by European countries where the road problem has been constantly before the public for years.

I would divide our main traveled highways into sections, varying from 8 to 10 miles, according to physical conditions. I would then place a man with a team and proper equipment in charge of each section, whose duty it would be to keep his section dragged, clean the ditches and culverts, and at odd times to repair and put on fresh surfacing material. Such men could be employed to good advantage for from six to eight months at a cost of about $100 a month. No man should be employed longer than he gives energetic, intelligent, and efficient service. No inquiry should be made as to his politics and there should be no hesitancy in his discharge for poor service.

VOLUNTEER SYSTEM UNSATISFACTORY.

It has been found from experience that volunteer or occasional dragging and repair work by roadside residents is not satisfactory. Personal affairs interfere with prompt and timely action, so I think that soon or later all States must adopt the system of constant, continued maintenance and repair by well paid employees, exacting from them the return for continued employment.

Every county should have a trained engineer as general superintendent of road building and bridge work, and these men will be rapidly developed if the compensation is sufficient to attract them.

In the meantime, pending the development of the patrol system, we are doing as much work as well as we can, but with the general policy of first opening a district to travel by a dirt road and later improving it, as traffic conditions and finance warrant.

We are particularly fortunate in Colorado, as we have much natural road building material, comparatively inexpensive, by the combination of which we can build the best of dirt roads. Our climate is such that maintenance costs are moderate, and, like most of the other States, our problem is one that rests chiefly upon the education of the public to the vital, economic need of good roads with a resultant increase in road appropriations which will enable us to cope with the tremendous increase in traffic which has made of many of our mountain roads veritable business thoroughfares, carrying all manner of vehicles day and night, winter and summer.

Machinery Keeps the Kansas Roads, Built of Local Material, in Good Shape

By W. S. GEARHART, State Highway Engineer.

THE gravel and macadam roads in Kansas have all been built of local material, and now that all of the available teams are needed for farm operations, the counties are making extensive use of motor trucks and trailers for hauling metal for the maintenance of these highways. The macadam is loaded from bins and the gravel with loaders. The material is spread by the trucks as it is dumped and afterward shaped with a grader and a spike-toothed harrow. By thoroughly harrowing the loose metal all of the cores are removed and the particles key together and take their natural position in the road surface. Harrowing saves at least one-third of the rolling otherwise required.

The power used for blade grader work on the earth roads is almost exclusively gas or steam engines or motor trucks. There are in the State between 6,000 and 7,000 privately owned large traction engines, and until the threshing season

WHERE MOUNTAIN AND
VALLEY MEET. TURKEY
CREEK NEAR DENVER, COLO.

opens in July, much of this equipment is available for highway work. The engine power is at least 50 per cent more efficient than teams, and on the smooth prairie or rolling country no difficulty is experienced in operating such equipment. Ordinarily two graders are pulled by one engine, and the graders are attached with an offset hitch so as to place the grader next to the engine out in the ditch and the second one just behind it. This keeps the engine on the solid ground and where it will roll and compact the loose earth as it is pushed into the road.

For cleaning the side ditches and smoothing the shoulders the road planer is used extensively. It is necessary to hitch a heavy drag behind the planer to spread the loose earth, which is shoved up into the middle of the road, and level it down to an oval cross section; otherwise the planer leaves the road shaped like a house roof.

Some 15 counties have purchased 5-ton motor trucks to haul road and bridge building materials and to pull their blade graders and planers. The large trucks are proving very satisfactory where they are used extensively for hauling materials, and the pulling of graders and planers is merely incidental or a minor part of the use made of them. When the majority use to be made of a truck is the pulling of graders and planers, it is not very economical, for just as good if not better power in other forms can be had at less cost.

In general, it is found not economical now for the county to own the power if good power can be hired for about $32 per day or $4 per hour.

The earth road dragmen are given from 1 to 5 mile sections of road to maintain, and they are required to drag the road whenever it needs it and to do all necessary ditch cleaning, repairing of bridges and culverts, and other incidental work. Since the dragmen live along the road they maintain, they take great pride in keeping their sections in good condition, and can do this work more economically than anyone else.

The average pay for each round trip with the drag is about 75 cents. These dragmen are generally strong believers in local control of road matters, and this gives them more supervision of the road they use most than they ever have had before and really all the work they can afford to put on the highway. Under these conditions they take very kindly to suggestions and advice from the county engineer, who has direct charge of the woek.

The State Highway Commission is urging that the earth roads be maintained to the highest state of perfection during the war.

Maintenance Yards are Established by California to Facilitate Work

By LESTER H. GIBSON, Assistant Highway Engineer.

THE maintenance of the California State highways has become a feature of considerable magnitude. There are now about 1,240 miles of paved highway and 1,060 miles of graded road in the system.

Maintenance yards are a necessity, and the commission has purchased sites from time to time and constructed buildings adapted to caring for the highways in their vicinity.

The largest yards are located in the more thickly populated centers and are used for supply, storage, and distributing points. They are also able to handle automobile and equipment repair on a large scale and to prepare asphaltic products for application on the pavements. Other yards vary in size and are located at junctions of the trunk lines with the laterals, and at convenient places along the highway.

Because of the extensive use of asphaltic oil and light asphalts for the thin surfacing on concrete pavements, nearly all of the principal maintenance yards are well equipped with heating plants where oil is received direct from the tank cars, stored in pits, and then, when needed, heated and pumped into the motor tanks for spraying on the pavement under pressure.

THE FRESNO MAINTENANCE YARD.

A maintenance yard of moderate size is located on the outskirts of the city of Fresno on the so-called Valley Route between San Francisco and Los Angeles.

The lot, which is 125 feet square, has street and alley frontage and is surrounded by a high fence of heavy woven wire with reinforced concrete posts, and a spur track from the Southern Pacific main line enters the yard, permitting oil or other materials to be unloaded without rehandling.

The asphalt heating plant is housed in a 27 by 18 foot corrugated iron structure. A horizontal boiler, of Scotch type, with a rating of 25 horsepower is fired by fuel-oil burners. It is possible to obtain 100 pounds pressure in one hour, starting cold.

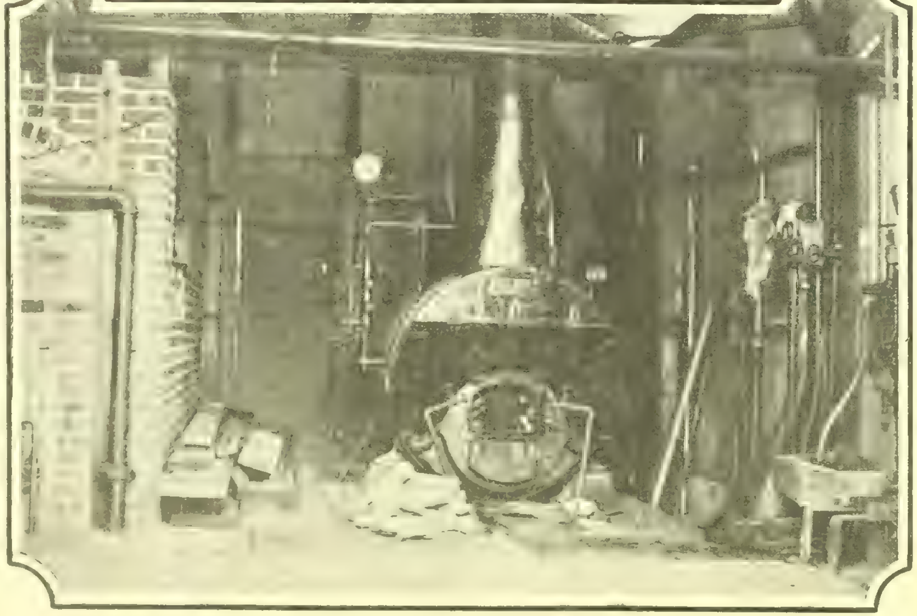
The retort is inclosed in brick, the heating chamber being roofed over with corrugated iron and banked with sand. It contains 14 runs of 3-inch wrought-iron pipe, each run being provided with a spiral 24-inch pitch. A baffle was inserted above

FRESNO MAINTENANCE SHOP

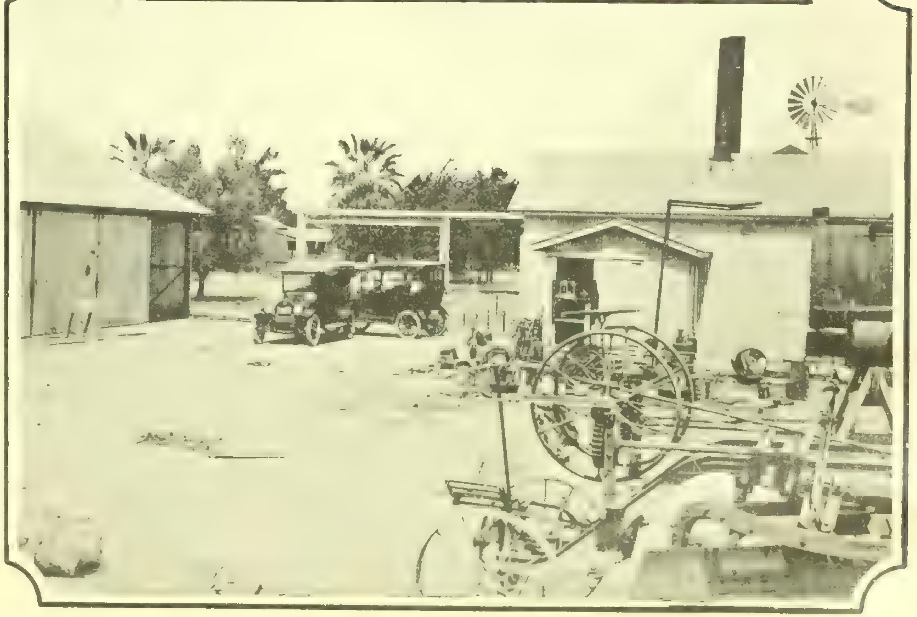
THE BUILDINGS

INTERIOR

OIL HEATING PLANT
RETORT, BOILER, PART OF PIPING SYSTEM



LOOKING TOWARD REAR OF YARD, SHOWING SHOP ON LEFT, AND HEATING PLANT BUILDING ON RIGHT.



the first layer of coils and the flames and heated gases are forced to traverse the full length of the retort, returning over the upper coils.

6,500 GALLONS IN FUEL-OIL PIT.

The fuel-oil pit is constructed of concrete and has a capacity of 6,500 gallons. Oil is delivered into storage by gravity direct from tank cars on the spur track. It is pumped directly from storage by a Witt fuel-oil set and is delivered at constant pressure to the burners under boiler and retort.

There are two concrete storage pits for asphaltic oil of 12,500 gallons capacity each. When tank cars are received on the spur their coils are connected up to the boiler until the asphalt is warm enough to flow, and they are then emptied by gravity directly into storage. It is possible to unload a 12,000-gallon tank car in about four hours. Coils are located in the storage pits sufficient to heat the oil so that it will flow through the gates into the heating pit.

The smaller heating pit is more amply provided with specially designed heating coils. Oil in this pit is heated by the coils until it reaches a temperature at which it may be readily pumped. It is then circulated through the retort until hot enough for spreading purposes, at which time it is pumped into the spreading tanks. A 1,000-gallon tank may be loaded in 10 minutes. Oil is loaded out at a temperature of about 350° F. A Bristol two-bulb recording thermometer keeps complete records of all temperatures in the heating pit and at the retort, being traced on the same chart and proving an effective guard against overheating. The chart also affords opportunity for comparative studies of work performed.

PATROLMAN LIVES AT THE PLANT.

A pump outfit consists of a Kinney No. 646 S. D. steam jacket pump directly connected to a 5 by 7 inch O. & S. steam engine. It is so arranged that oil may be pumped from any one point to any other in the plant.

The shop and storage building is of corrugated iron, covering ground area 60 by 30 feet, with eave clearance of 10½ feet. This building is equipped for handling minor repairs to auto trucks and equipment and provides room for storage of supplies and equipment.

A water-storage tank of 1,500 gallons capacity is on a tower adjoining the shop, the space beneath being inclosed and used for additional storage. The tank may be filled by electric or steam power.

A five-room frame cottage has been constructed in one corner of the yard, which is occupied by the patrolman for the district, and the need of a watchman is thereby obviated.

All space in the yard not occupied by buildings has been paved with concrete because of mud conditions in winter, but it also assists greatly in keeping the place neat and clean.

The Fresno maintenance yard was designed and constructed under the direction of J. B. Woodson, division engineer.

Montana Puts Its Greatest Effort Into Keeping Up the Market Roads

By PAUL PRATT, Chief Engineer.

IN common with several of the other western States, Montana has a difficult problem to solve in the maintenance of its highways. Large areas are being settled upon and developed into productive farming and ranching communities, and a consequent need for an ever increasing mileage of new roads stands forth as a primary and imperative necessity.

This necessity prevails not only in a few counties of the State but in all counties, and, as a result, construction and not maintenance has been, for a period of years, the important consideration of those whom the law has charged with the supervision of the highways.

Now, however, many of the roads recently constructed have begun to deteriorate to such an extent that road officials and taxpayers throughout the State are forced to recognize the necessity for immediate consideration of the maintenance feature of the problem. It must not be inferred that maintenance has been entirely neglected in this State. On the contrary, many of Montana's highways have been maintained in excellent condition. It is believed by the writer, however, that the present year will see the inauguration of intelligent, systematic maintenance programs in every county in the State.

VARIETY OF MAINTENANCE PROBLEMS.

Montana has something over 50,000 miles of roads outside the corporate limits of towns and cities. Practically none of this mileage is paved and probably not to exceed 1,000 miles have been artificially surfaced with gravel or broken stone.

Highways in the State generally have been built of local materials encountered along the right of way, and in consequence there is to be found a great variety of maintenance problems. The general highway law provides two general authorities for the supervision of care and maintenance work —viz, the county and the optional road district.

A maximum schedule of wages is fixed by law allowing the county or district to pay not more than $6 per day for man and team and $4 per day for a man. This limitation is probably the most serious difficulty to be surmounted. Abnormal conditions now prevailing practically prohibit the employment of competent and efficient help in all but very few sections of the State at the maximum wage allowed, and this results in either a well-meant effort to evade the strict interpretation of the law and get the work done, or an effort to do the most necessary work with inefficient help.

On designated State highways maintenance and improvement work can be performed by and under the State Highway Commission. Fortunately, no restrictions as to wages are placed upon the commission, and much-needed repairs are being, and will continue to be, made on several of the main routes across the State so long as labor is available. Very careful consideration is given to maintenance as well as to projects involving construction by both the highway commission and the various boards of county commissioners, before expenditures are made or labor utilized.

RECORD CROPS TO GO OVER ROADS.

Montana's response to the Nation's call for foodstuffs has been whole hearted and effective. Thousands of her acres formerly providing pasturage for her flocks and herds have been converted into fields of grain. A careful survey of the crop situation for the present year results in the prophesy that never in the history of the State have such enormous quantities of grains and other farm products been hauled over the roads as will of necessity be hauled this year. For this reason the efforts of all highway officials have been energetically turned toward the maintenance, improvement, and construction of those roads which will best serve in the marketing of food supplies. But little encouragement will be given in the promotion of sight-seeing and tourist roads. Realizing the heavy duty to which the market roads will be subjected, particular efforts will be made to so maintain them that they will be in the best possible condition to serve to advantage.

After the 1st of August all the available labor in the State will be required in the harvest fields to properly care for the millions of bushels of grain, thus necessitating that road work be practically completed by that time.

Montana will first help win the war by providing food for the armies and by maintaining those roads essential to the delivery of such food and food products. It will be time then to provide the roads for the pleasure seeker.

New Hampshire Uses Old Methods and Resorts to Local Materials

By JOHN W. CHILDS, Office Engineer.

CONDITIONS of maintenance in the State of New Hampshire are very unusual this year, causing greater problems to be faced than have ever been met since the advent of extensive automobile traffic.

The principal difficulty thus far encountered this season has been the lack of materials, rather than the scarcity of labor. To relieve the conditions resulting from the lack of road oils this department has resorted to methods used before binders came into extensive use in this State. By applying a light coat of surfacing gravel and sand, with constant care on the part of the various patrolmen in keeping the material on the road by dragging, we hope to hold the gravel roads in shape during the coming season.

Whatever oils or tar products we are able to obtain are being used on the main trunk lines where traffic is of such a nature as to prohibit such methods as are sufficient to keep the State-aid roads in shape for local traffic.

In other words, it is hoped that, by the judicious use of what oils are obtainable and by the efficient working of the patrol system, the highways of the State will accommodate the ever-increasing traffic, at least for the present season.

Some local quarries of trap rock are being exploited by the State highway department which are producing stone of a quality equal to or better than that hitherto imported from outside the State. This has relieved the department to a certain extent from the dependence on rail shipments to two Federal-aid projects and some other work.

The labor situation this year is for some unaccountable reason much improved over that of last. No difficulty has been encountered as yet in the employment of common labor, although the price is about 30 per cent higher than during normal times.

The cost of maintenance has not been backward in following the trend of the times and is from 30 to 100 per cent greater than normally. However, it is not expected that the maximum has yet been reached.

An important factor in relation to the present and future condition of the highways in the State of New Hampshire is the ever-increasing traffic. Commercially this is at least 100 and in some places even 200 per cent heavier than ever before. However, the greatest increase seems thus far to be in the tourist traffic from outside the State. This is evidenced by the extremely heavy Sunday traffic, and is noteworthy in that a large percentage of automobiles includes small cars. It may be that the increased wages in this section are being spent in this way, but whatever be the cause the fact remains that they are here to be accommodated by our highways.

The worst feature of this new traffic is that it seems to be available only for week-end tours, with the principal object in view to cover as much ground as possible, resulting in the abuse rather than the use of the roads. It is expected that an organized traffic census will be in force soon, so that a definite knowledge of conditions will give a comparison with the traffic of normal times.

As to results of the methods in use now in the matter of maintenance, time only will tell. All that can be hoped for is that conditions will at least become no worse than at present.

Illinois Roads in Good Condition Despite Delays and Higher Prices

By H. B. PIEPMEIER, Maintenance Engineer.

ILLINOIS has approximately 95,000 miles of public highways, of which about 12 per cent have been improved with some kind of hard surfacing material. Under the exsiting State aid law, which has been effective since July 1, 1913, there have been constructed approximately 400 miles of hard surfaced roads and about 300 miles of earth roads.

The State has general supervision of the maintenance of all State aid roads. When these roads are built of concrete, brick, or bituminous concrete on a concrete foundation, the entire maintenance cost and the performance of the work are taken care of directly by the State. In the case of gravel and macadam roads the State supervises the work, and the maintenance cost is borne equally by the State and the county. In the case of earth and oiled earth roads the entire maintenance cost is paid by the county. The township highway commissioners are responsible for the maintenance of all roads which have not been improved under the State-aid law.

It is evident that systematic maintenance of all roads is a necessity. The economy of many types depends almost entirely upon the way they are maintained. In view of this condition, the State division of highways is exerting every possible effort to maintain all State roads in a condition of greatest serviceability commensurate with economy, and to influence all township road officials to do the same.

NEW CONSTRUCTION ONLY AS WAR AID.

On account of abnormal conditions, the State department is in no way encouraging construction work unless it is evident that such work will be a direct aid in winning the war. The department is further attempting to impress upon all road officials the necessity and economy of taking special care of all roads that have heretofore been constructed. This year unusual effort is being made to get all earth roads drained and a systematic plan of dragging adopted. On account of the large mileage of earth roads, any scheme which may be inaugurated to secure better drainage and a smooth earth surface will materially aid the people in marketing the farm products of this State.

In an agricultural State such as Illinois it is ordinarily difficult to secure the teams necessary for road construction and maintenance. Frequently the heaviest demand for road maintenance comes at a time when the farmers need all the extra teams and labor. The shortage of teams and labor this year is very noticeable, with the result that the rate of pay in many places is 25 per cent higher than in previous years. These labor conditions have caused delays and consequently extra work. As a result, maintenance cost has been increased from 15 to 25 per cent.

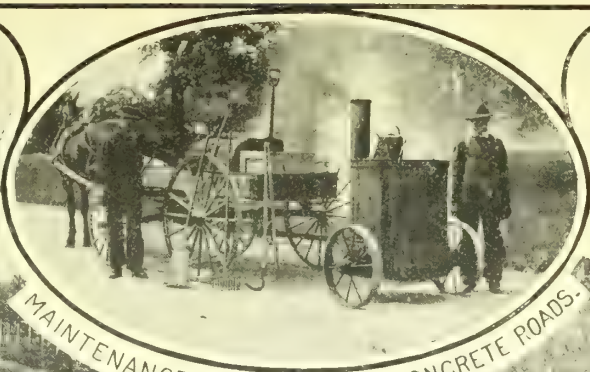
With one or two exceptions the mileage of improved roads in any one locality is so limited as to prohibit the use of a permanent maintenance gang. State maintenance work, therefore, is more or less at the mercy of labor that must be secured at the various points where the State aid roads are located. The maintenance of State roads is therefore necessarily high in cost and difficult in execution.

HARD TO DO WORK ECONOMICALLY.

In the 102 counties of Illinois there have been constructed to date about 300 distinctive sections of hard-surfaced roads, aggregating in length about 400 miles. The average length of each section is about 1½ miles, the longest section being about 8 miles. It is readily seen that where roads are isolated in this way it is difficult to do all work economically.

Practically all field maintenance work on State-aid roads is handled by regular maintenance foremen, who are supplied with a light truck of 1 ton capacity or less. The light truck enables the foreman to carry all the necessary equipment and an assistant or helper. With the light truck it is possible for one foreman and his helper to do work at two or three different times each season on 50 to 100 miles of hard roads.

A GOOD EARTH ROAD IN NOVEMBER MAINTAINED BY SURFACE OILING.



MAINTENANCE GANG REPAIRING CONCRETE ROADS.

A MACADAM ROAD DESTROYED AS A RESULT OF NEGLECTED MAINTENANCE.

A GRAVEL ROAD COMPLETELY DESTROYED ON ACCOUNT OF POOR DRAINAGE.

ILLINOIS' CHIEF ROAD PROBLEM.

There are very few deposits of road-binding material in Illinois that can be utilized for maintenance work. It is necessary, therefore, to ship practically 90 per cent of all materials needed for repairs. Most shipments comprise small orders and this results in many delays and some additional expense. In a few places local material plants have been developed and a portion of the output utilized for maintenance work.

A large per cent of the State-aid roads in Illinois have been constructed of concrete. This type of road requires annual maintenance in that all cracks and joints must be kept filled with asphalt or tar. This work requires approximately 100 separate shipments of from one to five barrels of bituminous material. Such small orders are necessarily expensive and often cause many delays. This is especially true this year, as less than car-load shipments require apparently from two weeks to ten weeks for delivery.

WILL PUT ALL ROADS IN CONDITION.

During the past few years Illinois has used considerable road oil for earth road maintenance. This year the shortage of petroleum products and the excessive cost of a suitable material has reduced this practice by possibly 80 per cent. It is hoped that this may result in diverting more attention to the use of the road drag.

A comparatively small mileage of macadam and gravel roads has been maintained by surface treatments of asphalt or tar. It is hoped, therefore, that in the case of the few roads which will need surface treatments there will be little trouble in getting sufficient bituminous material.

While many delays and higher prices for all maintenance work have been experienced, most roads have been thus far properly maintained, and barring unforeseen conditions there is every indication that all roads will be kept in good condition during 1918.

Wisconsin Adopts the Patrol System and Obtains Most Gratifying Results

By J. T. DONAGHEY, Maintenance Engineer.

WISCONSIN road laws naturally divide our 77,000 miles of public highways into three classes. Class A embraces those comprising the State trunk highway system of 5,000 miles, which are intercounty roads of State-wide importance, provided for and maintained under the provisions of the State trunk highway law. Class B contains the portion of the county system of prospective State highways commonly known as the State-aid system, lying in each county which is not included in Class A, and consists of about 15,000 miles. Roads in this class are generally intertown roads of county importance only, and portions of such roads previously improved by the county are maintained by the county and the balance maintained by the town in which they lie. Class C comprises the balance of the roads in the State, 57,000 miles, which are generally roads of local importance only and maintained by the unit of government in which they lie.

The total mileage of the three classes is divided under the different types of road approximately as follows:

	Miles.
Concrete, brick, and other high types of surfacing	250
Stone and gravel macadam	2,300
Pit run gravel	9,500
Shale	600
Sand and clay	1,600
Earth	62,750

$1,500,000 FOR CLASS A MAINTENANCE.

Class A roads in each county are maintained under the provisions of the State trunk highway law, according to the directions and specifications of the State highway commission, and the cost is paid out of funds derived from the automobile license fees. The amount available for maintenance of Class A roads in Wisconsin for 1918 is approximately $1,500,000.

The State highway commission has installed a patrol system of maintenance covering the entire State trunk highway system, dividing the trunk highways lying in each county into sections from 6 to 10 miles each, employing a patrolman, who furnishes team and wagon, on a monthly basis for the entire maintenance season. The patrolman has immediate charge of the maintenance of his section under the direct supervision of the county highway commissioner. His equipment consists of a light road grader, road drag, road planer, plow, slip scraper, and the necessary small tools. He has authority to employ extra help when necessary in order to keep his section in first-class condition at all times.

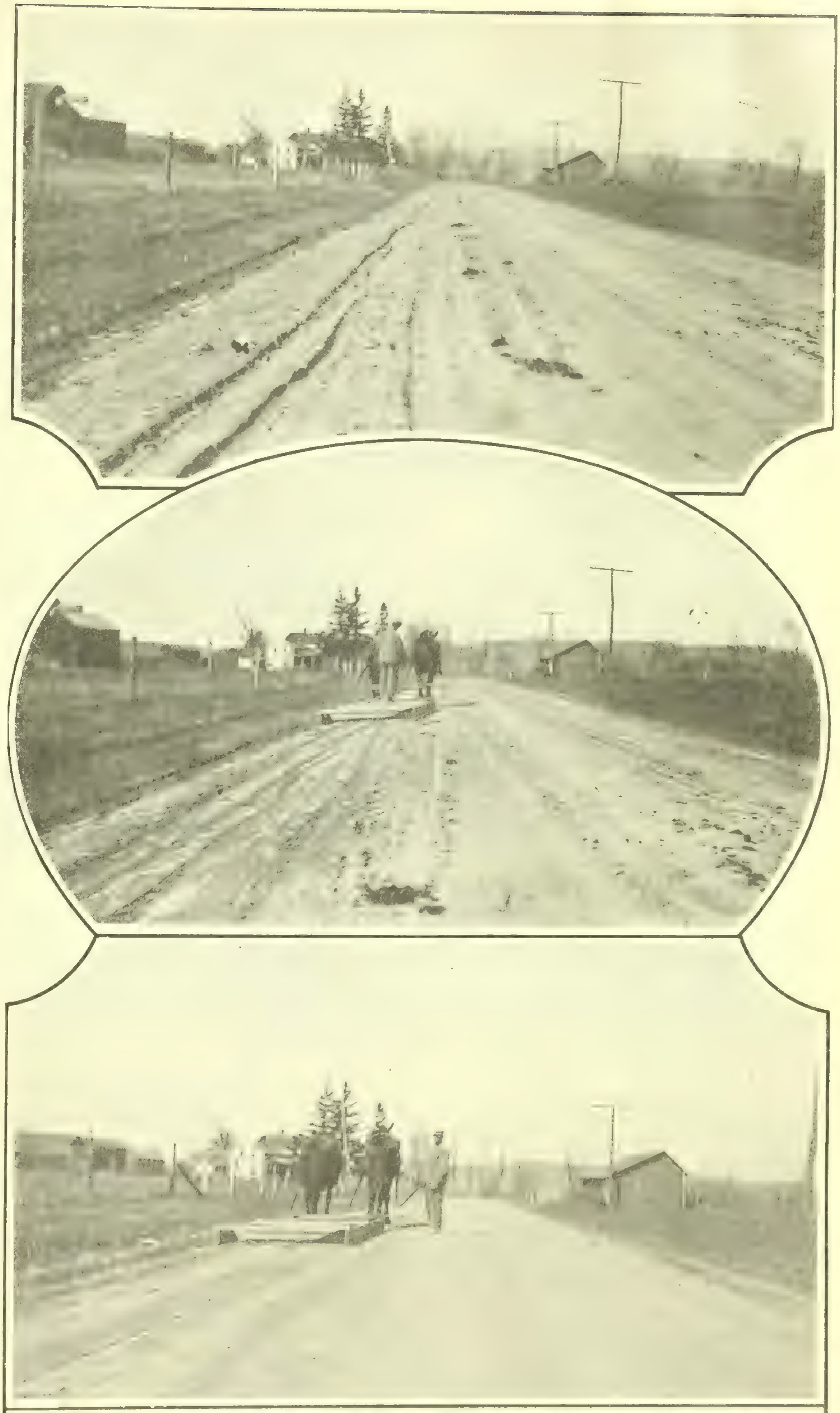
Heavy grading work, resurfacing, or surface treatments of stone and gravel roads is done by a county maintenance gang.

On surfaced sections the material for maintaining the surface is delivered to the roadside by motor trucks furnished by the county, and in some instances hauled by teams during the winter months where winter hauling is practical. The majority of our counties, however, are now using motor trucks for this purpose.

GREAT IMPROVEMENT IN CONDITION.

The entire 5,000-mile system was taken over May 1 and patrolmen placed on each section, and a month later the change in the condition of the system was wonderful. From the reports received from our organization, as well as from the general public, we are led to believe that the actual condition of the roads on the State trunk highway system then was 100 per cent better than at the same period in previous years.

Class B roads (where construction has been done by the county in the past) are maintained by the county out of funds also derived from the automobile license fees, together with certain funds appropriated by the several counties. Several of the counties have adopted the same plans for maintenance of the Class B roads as is used on the State trunk system and have divided Class B roads into



SECTION OF WISCONSIN STATE TRUNK HIGHWAY WEST OF BARABOO. HEAVY CLAY SOIL, RATHER POORLY DRAINED, AND CARRIES RATHER HEAVY TRAFFIC FOR AN EARTH ROAD. TOP VIEW TAKEN AT 9 A M. FOLLOWING HEAVY RAIN. PATROLMAN HAD MADE A TRIP ONE WAY ON THE CENTER OF THE ROAD WITH A ROAD PLANER. IN CENTER – 15 MINUTES LATER, FOLLOWING PATROLMAN'S RETURN TRIP. BOTTOM – AN HOUR LATER AFTER PATROLMAN HAD COMPLETED SECOND ROUND TRIP WITH PLANER.

patrol sections, doing practically the same class of work that is being done on the State trunk system. Portions of the Class B roads that require resurfacing or surface treatment are handled by the county gangs organized for this purpose. For the maintenance of this class of road we have available approximately $600,000. Many of the Class B roads are really as important and carry as heavy traffic as those of Class A, require practically the same form of maintenance, and are handled by the county in practically the same manner.

Class C roads are maintained entirely by the local town board under the direct supervision of local road superintendents. Some of the superintendents do excellent work, while a great many of them have but few constructive ideas. A few towns have adopted the plan of dragging the Class C roads when necessary, but, taken as a whole, the money expended for their maintenance is not well spent because of the fact that no central organization has direct control over them.

DEPEND LARGELY ON LOCAL MATERIAL.

For the maintenance of the Class A and Class B roads we are using local materials almost entirely. In the majority of counties in which there are surfaced roads there are good local gravel pits or stone quarries which are being used to good advantage. In many instances we are hauling material by motor truck or by teams during the winter months a distance of from 3 to 10 miles at a very reasonable cost. On our stone and garvel macadam roads we are aiming to maintain all such that can be maintained without a surface treatment due to the high price of oils and tars and the uncertainty of getting them when required. Fine crushed stone containing the dust and fine clay gravel used properly maintains the poorer macadam roads very cheaply.

We are not handicapped to any great extent for labor on maintenance work. The construction program in the State is considerably reduced due to war conditions and the different counties are transferring their construction organizations into the maintenance work. Although the price is somewhat higher than in previous years, by the use of modern machinery it is possible to keep the maintenance cost down to probably 20 or 25 per cent over that of past years.

Motor traffic on our mail lines of travel is increasing rapidly, making them more difficult to maintain, but by the introduction of the patrol system of maintenance we find it possible to maintain reasonably heavy traffic on earth or gravel roads at a cost not to exceed $200 per mile per year.

Pennsylvania Planned Long Ahead to Meet Labor and Material Needs

By GEORGE H. BILES, Maintenance Engineer.

WITH a road system such as Pennsylvania has of over 10,000 miles of various types, as shown in the table below, innumerable problems have to be solved continually to approach anything near a satisfactory degree of efficiency under the existing abnormal conditions brought about by the war:

	Miles.
Earth	6,693.575
Gravel	232.940
Flint	103.460
W. B. macadam	2,387.872
Bituminous macadam	144.470
Asphaltic concrete	118.756
Concrete	36.079
Brick	271.639
Toll	213.035
Stone block	3.112
Bridges	7.345
Total	10,212.283

The fundamentals in our State at the present time, of course, are labor and materials. Pennsylvania, being an industrial State and the workshop of the whole country in its present crisis, has called to this field the bulk of the man power. In addition, all transportation facilities are about taxed to their utmost in the handling of the sinews of war. This condition calls for the application of heroic measures and expedients to keep in repair the main arteries of travel, which to-day are being subjected to unprecedented traffic by all classes of vehicular transportation.

PLANNED WORK LONG IN ADVANCE.

Having compiled statistics of our resources and geological deposits during the course of several years of our maintanance opearions, it was possible to plan this work long in advance of the actual working season. The greatest asset, we believe, to a highway organization, and more especially in an era such as we are passing through at the present time, is system. Without the statistical data, Pennsylvania, under present conditions and considering the scope and character of the work, would be in a chaotic state. In localities where extensive repairs were scheduled and material was accessible, quarrying operations were carried on through the winter months and the material crushed and hauled along the road ready for use when the proper time arrived.

This arrangement had a twofold purpose; first, it provided the necessary material, and, second, it permitted the use of the same force of employes who were transferred to the road site to carry out the work on the proposed project, thus offering more steady employment to the workmen and making the work more attractive to the local class of labor.

EXAMPLES OF PENNSYLVANIA MAINTENANCE. TOP-SURFACE TREATED WATER BOUND MACADAM. BOTTOM—EARTH.

START WORK EARLY IN SPRING.

Depending, as the State highway department does, mostly on labor in the rural sections, the work on the large unimproved mileage is started early in the spring as soon as weather conditions permit and an effort is made to accomplish as much as possible before many of the workmen are called to imperative agricultural work. Crews of experienced roadmen are organized and are transported in motor vehicles to districts where conditions are adverse, and in this way the work, in general, can be taken up at the proper time and carried out more uniformly.

A very large proportion of the work depends entirely upon the transportation of material over the railroads, and the department has been working through all State and governmental agencies for assistance in this respect. It, however, is not by any means only a question of transportation, for the sources of supply have become limited and those operating have their output contracted to such an extent in Government orders that it is difficult to get shipments except in cases of extreme emergency.

STONE ROADS GREATEST PROBLEM.

The maintenance of the many miles of stone road in the State system is the paramount problem in our work to-day. In sections where it is impossible to obtain shipments of road materials, the best materials and combinations that can be gotten locally are being used as temporary expedients. The stone road, under present conditions, requires surface treatment to withstand the ravages of the ever-increasing and changing traffic. On stone roads, which are not representative samples of first-class macadam construction, such as the old turnpikes and also light traffic or secondary roads, light dust allaying preparations are used which require little more effort than the actual application of the material with the motor pressure distributor.

The first-class hot and cold treatments which are used only on roads in good condition, call for the force of road cleaners and men to cover the surface with stone chips, small gravel or sand, fast enough to take care of the capacity of the pressure distributor. The crews employed in this work are taken from place to place, following the one distributor through the entire district, when possible.

SLAG CHIPS FOR COVERING MATERIAL.

The bituminous treatment schedule has been so classified that several products were specified, thereby distributing the whole schedule among several companies, and thus obtaining the advantage of having the application made simultaneously and insuring an early completion, which will not only make it possible to complete the work in time for the period of heaviest travel, but will release men for other work.

Covering materials have been the cause of very great concern, and to overcome this, in a measure, hard, clean slag chips which were a by-product during the winter months at the slag plants that were working on Government contracts were contracted for and delivered at the time. This arrangement has proven of great advantage, and in certain districts the work is progressing up to the schedule time.

In certain localities small portable crushing plants are being used to manufacture stone chips, and considerable quantities of acceptable gravel and coarse sands are being used. Unloading plants, motor trucks, small tractors, and mechanical devices are being used wherever practicable to conserve men and teams.

ECONOMIC PHASE IMPORTANT.

Where work of such magnitude must be prosecuted at all hazards under present conditions, the economic phase of the question is one of great importance on account of the fact that the resources or appropriations for the work do not increase proportionately with the abnormal increase in the cost. As an example, labor and material have advanced more than 100 per cent, while the available funds probably will not amount to 30 per cent more than last year. In addition, the general repair work will be more extensive, due to the increased use of the roads. It is anticipated that delays will be experienced due to the unusual conditions, but in due season it is confidently expected that the roads will be put in good travelable conditions.

Pennsylvania has been and will continue to cooperate to the limit of its resources with the National Government in the maintenance of the highways, particularly those used in this great war crisis for military purposes.

Portable Machine and Auto Truck Reduce the Difficulties in Michigan

By L. H. NEILSEN, Maintenance Engineer.

WITH about 6,000 miles of State-aid roads, a large part of which have a gravel surface, to consider, the problem of maintenance in Michigan is looming up in large proportions.

Recent legislation has put the responsibility for the condition of State aided roads squarely up to the State highway department by giving full authority to it to do the work necessary to place any deteriorated road in good condition and charge the cost up to the township through the auditor general. The municipalities must arrange also for a maintenance system that is satisfactory to the department before further State reward can be paid on new work. At the beginning of this year a division of maintenance was organized and maintenance work will be followed more closely than ever.

A considerable number of counties have organized extensive patrol systems for the maintenance of earth and gravel roads. Due to varying local conditions these systems are quite different in detail, but the essential feature of continuous maintenance is preserved in all of them.

In many cases one man provided with a wheelbarrow and the necessary small tools takes care of a section of road. He calls out local men with teams to float the roads whenever, in his judgment, that is necessary. Materials for patching are stocked at short intervals.

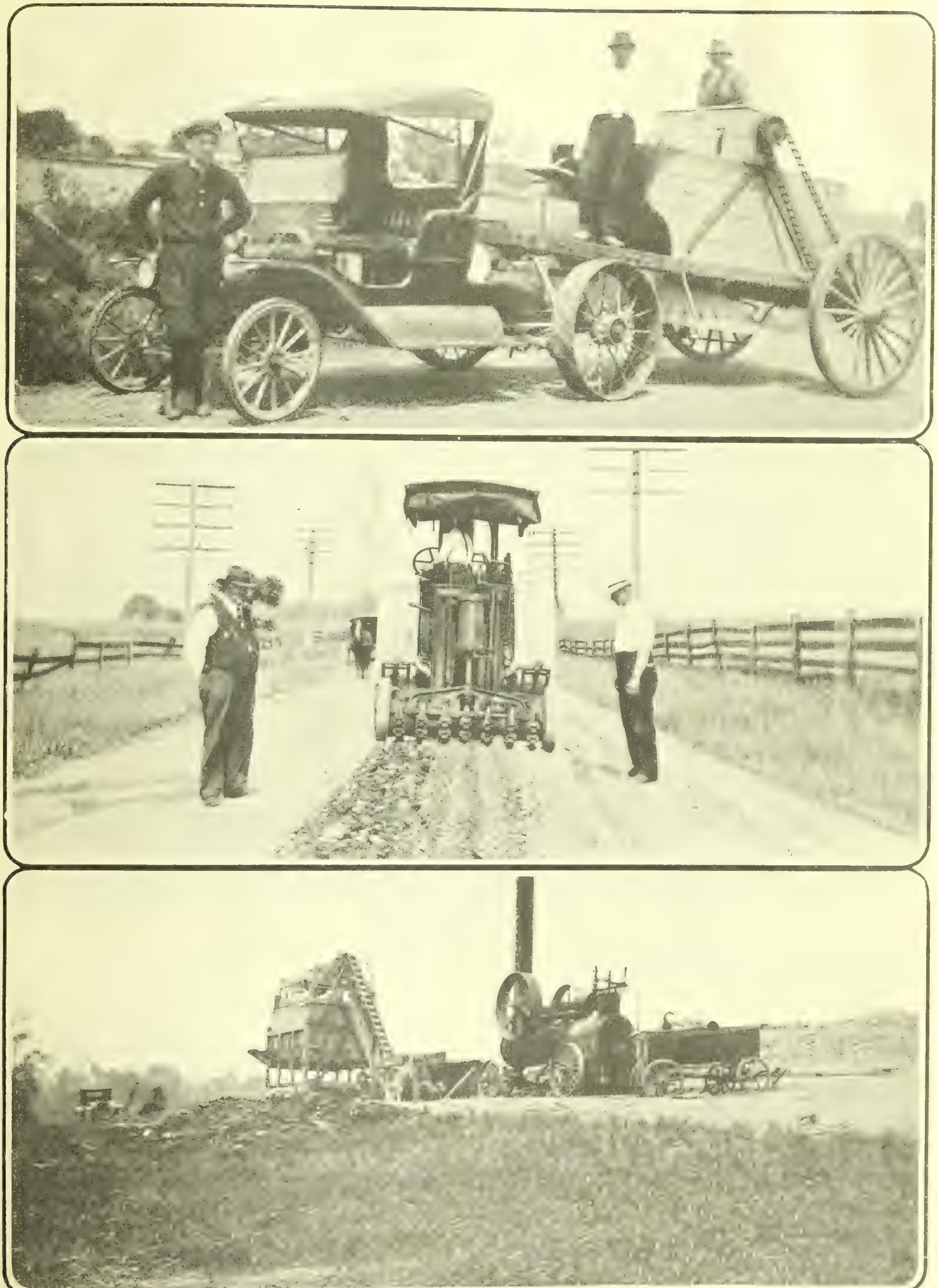
PUT BURDEN ON PATROLMEN.

Several localities have placed a man, single horse, and one-horse wagon on the roads. In such cases a light road float is furnished, the patrol man doing the necessary floating. Stock piles can be placed farther apart, but it would still be necessary to provide for the placing of repair material by independent gangs.

Several counties are using patrolmen with teams and wagons. They also do their own floating and in many cases haul their own repair material from the pits.

Gangs have been used for doing maintenance work on earth and gravel roads, but are not looked upon with favor, since their use tends to increase the interval between successive trips over the road. On hard surfaced roads and pavements, however, their use on shoulder and ditch work has been very satisfactory.

Where only isolated pieces of road occur, the employment of farmers who give as much time as may be necessary to the road seems to be the only practical method. This method is, however, open to the



MECHANICAL AIDS IN PENNSYLVANIA MAINTENANCE

TOP—MECHANICAL STONE CHIP SPREADER WITH IMPROVISED MOTIVE POWER. CENTER—ROAD ROLLER WITH SCARIFIER ATTACHMENT. BOTTOM—ENGINE, CRUSHER, AND BIN FOR CRUSHING FIELD STONE.

objection that it is extremely difficult to get the work done at the proper time.

The success of any of the above methods depends upon the amount of supervision given.

TRIP A DAY OVER EACH ROAD.

On some of the heavier traveled gravel roads we have found that continuous floating with a road float gives very good results. In these cases a trip is made over each road every day regardless of weather conditions. It is necessary to add gravel in such amounts as will insure that there is always a thin layer of loose material present on the road surface. This gravel should not contain pebbles larger than one-half to three-fourths inch and should contain a sand or loam filler.

On limestone macadam roads patrols are also used to some extent. The usual practice is to give a bituminous surface treatment consisting of a cold application of from ¼ to ⅓ gallon per square yard. This is followed in the first instance by another treatment of ¼ to ⅕ gallon per square yard of the same material applied as soon as the first one is dry. The second application is covered with a pea gravel from ⅛ to ⅝ inch in size or washed limestone chips from ¼ to ¾ inch and then rolled with a power roller. The following year the road is patched and another light treatment placed. These applications are continued as often as required.

As soon as sufficient mileage has been put under surface treatment to warrant the expense, a light truck with two men is placed in commission. This unit patrols the surface-treated roads at intervals, patching the bituminous surface with the proper material. Either heated material is used in combination with pea gravel or clean limestone ships, or a premixed combination of sand, stone, and cold bituminous material is carried in the truck to fill the holes.

FIND ECONOMY IN LOCAL MATERIAL.

Bituminous surface treatments have also been used with success on crushed cobblestone macadam.

We have also used 2 to 3 inches of a loam filler gravel for resurfacing macadam roads, the maximum size of pebbles ranging from ½ to ¾ inch. The road is then patched in the same manner as the gravel-surfaced roads. This is very economical and local materials can be used.

On crushed-gravel roads bituminous surface treatment has been satisfactory to some extent, although a large amount of patching is required and a wavy surface usually results.

The use of portable crushers and screens and gravel screens alone has in many cases enabled us to secure materials for maintenance in spite of car shortage. Motor trucks and in some cases tractors and trailers have replaced team hauling to a great extent.

Our reports on maintenance will not be available for some time, and it is hard to tell at this time how the condition of roads will compare with last year, as a great many of the organizations are new and are not yet operating at normal efficiency.

Washington's Work is Well in Hand; Roads are Reported in Good Condition

By GEORGE F. COTTERILL, Chief Engineer.

WASHINGTON State highways are under joint maintenance responsibility prescribed by law, combining State regulation and enforcement of standards with direct county administration.

The State highway board has defined the standards and established a uniform system for cost-keeping and reports, which control the maintenance and repair of the primary State highways constructed in 30 counties, and with a 1917 total of 1,243.77 miles. For 1918 this will increase to about 1,442 miles.

This joint maintenance system is set forth in detail in the Washington State Highway Department Bulletin No. 10, containing the "Rules, Regulations, and Requirements for the Maintenance of Primary Highways as prescribed by the State Highway Board." It is based upon four fundamental features, viz:

1. A series of county maintenance funds, apportioned by law from certain State funds (mainly motor-vehicle license revenue), assuring each county at least $100 per mile annually for its permanently improved primary highway mileage. (N. B.—1918 county totals in all cases exceed $200 per mile). These funds are available only for maintenance and repair, with necessary equipment, upon (*a*) the constructed primary State highways, and (*b*) other main county highways improved to a standard legally defined as "permanent highway" construction. The mileage in the latter class somewhat exceeds that in the first, making a total of about 3,000 miles of permanent highway construction on primary State and main county highways. If the county maintenance fund for any reason proves insufficient for primary highway maintenance, two

other county credits are obligated to provide any deficit. Maintenance has prior claims on three funds.

ADVANCE ANNUAL ESTIMATES.

2. Advance annual estimates, prepared by county engineers in direct charge of maintenance, covering all expected maintenance, requirements, compiled separately for each section of continuous, similar construction and surfaced type of highway (short bridges and other structures included in their respective sections). These estimates are required on uniform State forms, with segregation of maintenance and repair costs under defined item headings. Estimates are first submitted to county boards of commissioners for review, with right to modify, followed by approval and appropriation of totals, which become an advisory budget for the respective county engineers. Certified copies of all sectional annual estimates are transmitted to the State highway commissioner, who has final review and right to modify as necessary in his judgment for adequate maintenance provision.

3. Monthly reports of actual expenditures, prepared by the 20th of the following month, by responsible county engineers in direct maintenance charge, certified both to county commissioners and to State highway commissioner for State records. These monthly reports are on uniform series of forms provided by State highway department, with segregation of items, division of highway sections, etc., corresponding to the annual estimates. The column arrangement of these monthly reports carries forward each month a simple system of budget bookkeeping charged against the approved annual estimate and appropriation.

4. Reserve enforcement power of the State highway board by which, in event any primary State highway section is not maintained in accordance with prescribed standards, the State highway commissioner may cause direct maintenance work to be done until such standards are reached. This action can be taken only after 15 days' notice to responsible county authority, and continued delinquency. Payment for such direct State work is a prior claim upon the county maintenance fund, and if necessary upon the the two other county reserve maintenance credits.

From June to December, 1917, the 30 county engineers reported expenditures totaling $210,829 upon 1,244 miles of primary State highway, or an average of $169.50 per mile for seven months' maintenance, repairs, and general upkeep of these main-traffic highways of the State. In the various counties the average maintenance charge ranged from $14.29 up to $498.91 per mile. These great variances arise from unusual repairs, incidental improvements charged as maintenance, equipment purchases, and supervision charges, as well as from varying traffic wear and construction types.

With this seven months' experience of 1917 requirements, the 30 county maintenance administrations estimated and appropriated in January, 1918, a total of $480,000 for the full calendar year of 1918, or an average of $333 per mile for the 1,442 miles of primary State highways covered by the estimates. In these 1918 budgets the various county averages range from $137.58 up to $1,372.84 per mile as an estimate of their maintenance requirements. The reports thus far at hand cover actual expenditures for the first four months of 1918, showing a total slightly exceeding $160,000 or almost exactly one-third of the total annual budget for the first third of the year.

COMPARATIVE MAINTENANCE COSTS.

An interesting series of comparative maintenance costs for the various highway construction types is available from the 1917 record. The figures for a single (and fractional) year, qualified by many special and local considerations, are only circumstances upon which it would be unsafe to base any convincing conclusions. The 1918 figures will add greatly to comparison values, but it will require at least four years to produce statistics and averages which will fairly present comparative maintenance costs. At present these figures must be applied with special analysis of the detail reports for local sections.

PRIMARY STATE HIGHWAYS.

Expenditures for maintenance and repair, June to December, inclusive, 1917.

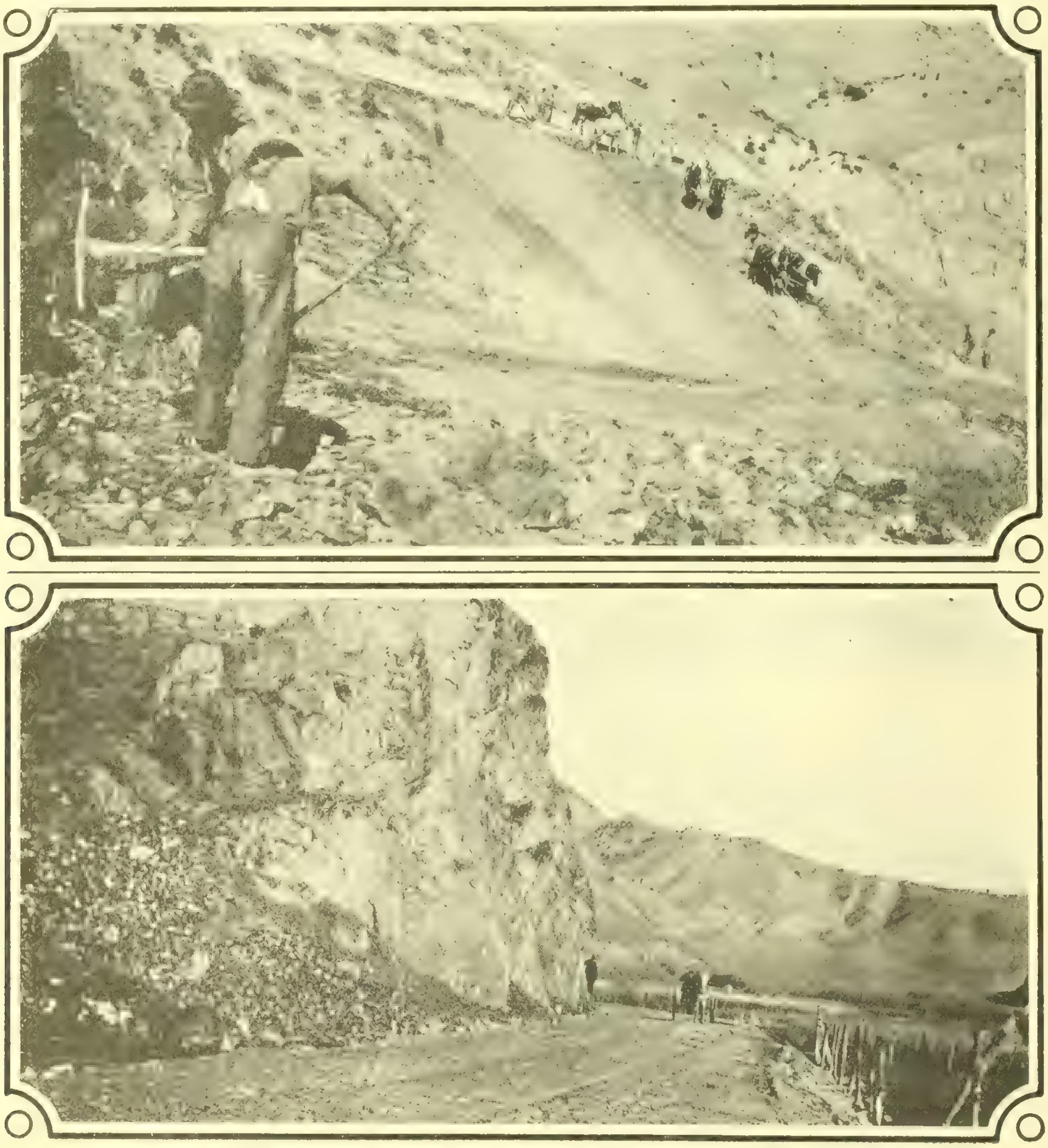
Type of highway.	Mileage maintained.	Expenditure.	Average per mile.	Sections reported.	Number of counties.	Remarks.
Brick pavement.....	8.81	$9,456.51	$1,073.38	4	1	Including extensive replacement.
Concrete pavement...	90.59	5,092.45	56.21	20	10	1 to 4 years' use.
Asphalt pavement....	5.97	326.03	54.61	3	2	Do.
Asphaltic concrete....	19.74	319.76	16.19	5	2	Mostly first year, nominal maintenance.
Bitulithic, including Warrenite.	14.41	2,978.50	206.70	3	3	1 to 7 years' use.
Bituminous macadam	40.21	5,493.49	136.62	12	6	2 to 8 years' use.
Macadam, also crushed rock surfacing.	135.74	24,282.44	178.89	31	12	1 to 10 years' use.
Gravel surfacing..	816.56	144,362.87	176.79	94	[illegible]	Do.
Natural earth grade..	109.74	11,043.37	100.63	12	4	
Bridge and trestle, decking and repair.	2.00	7,474.47	3,737.23	[illegible]	[illegible]	Mainly new decking, Snake River bridge.
All types	1,243.77	210,829.89	169.50	[illegible]	30	

Highway maintenance is well in hand for 1918, with ample provision despite fully 50 per cent increased costs of the war period. Scarcity of labor is apparent and becoming more acute. Car service occasions little difficulty, as local materials are available for most maintenance needs. All reports indicate our State highways in good condition and well maintained. Traffic requirements are constantly increasing, and these main roads are proving their usefulness with each added mile of permanent improvement.

Power Operated Machinery Saves Both Time and Money on the Roads of Utah

By IRA R. BROWNING, State Road Engineer.

JUST as the national needs for feeding and equipping our armies and our allies have stimulated production of foodstuffs, forage, and all materials that are military and industrial necessities, so the imperative need for increased transportation facilities has stimulated road construction, improvement, and maintenance.



MACYSVALE—SEVIER ROAD, PIUTE COUNTY, UTAH.
TOP — SCRAPING ROCKY LOAM FROM HILL SIDE TO MAKE FILL IN SWAMP AROUND OBSIDIAN CLIFF.
BOTTOM — VIEW OF COMPLETED ROAD AROUND OBSIDIAN CLIFF.

The argument that increased production is ineffective unless adequate means for transportation are furnished, can not be satisfactorily answered except by good roads connecting the producing areas with shipping points and market centers.

The scarcity of labor for road construction and maintenance has been an important factor, not only in limiting the road work to the absolutely essential highways, but also in providing mechanical equipment and power operated road machinery to a more marked extent than ever before. While the initial cost of this equipment is a considerable item of expense in connection with the State road work in Utah, the results achieved and the reduced cost of construction and maintenance, have already demonstrated the advantage of power-operated road-building equipment as compared with construction involving horse-drawn implements.

WHAT MACHINERY ACCOMPLISHES.

A typical case was the grading of a road in Utah County, using a heavy grader drawn by a tractor. The total cost was less than $30 per mile; while with horse-drawn plows, scrapers, and graders the expense would have been at least $150 per mile for the same road.

The use of the road scarifier drawn by either a truck or a tractor, for reducing the irregularities on a gravel or macadm road, and providing a bond for new surfacing material, affords another illustration. The steady pull on the drawbar of a tractor or large truck, together with the uniform speed and the perfect control, render the operation of scarifying roads with power-drawn equipment twice as efficient or at one-half the cost of the same work with horse-drawn implements.

The use of the steam shovel on heavy cuts and side-hill construction, especially in view of the advanced wages for men and teams, has solved a very serious problem in road construction. With the operation of two or three shifts per day the steam shovel can save its original cost in actual reduction of unit cost of excavation in the course of a few months.

The use of portable compressors and jack-hammer drills has done much toward reducing the time and labor for cutting out defective areas and patching and maintaining hard surfaced roads; also for the removal of intrusive points of ledge rock and the bowlders encountered during excavation.

PATROL SYSTEM FOR MAIN ROADS.

The maintenance of earth and shale or gravel surface roads is becoming more of a problem as the traffic and intensity of loading increases. The labor of repairing and maintaining these highways is therefore sure to increase. It has been demonstrated in Utah that the greatest saving and improvement is effected by establishing a patrol system for the main roads. If a foreman residing along the road has a 10-mile section extending each side of his home, and he is authorized and encouraged to plan ahead for the requirements of his road section, he will have piles of material suitable for repairing ruts and maintaining the road surface in good condition at convenient points along the road. He will so plan his work that the grading, crowning, dragging, and draining of the roads will be attended to at the proper time, even though this may be outside of the ordinary working hours.

Allowing a road section foreman the initiative and placing upon him the responsibility of maintaining his road in commendable condition for traffic has proved, where the foreman had ambition and capacity, the most economical and effective system yet devised and tested in this State.

The present plans of the State road commission include a power unit, such as a tractor or heavy truck, for each county; also the extension of the road patrol system to cover all of the principal State roads.

New Jersey Has Millions to Keep Up Roads But Finds the Task Difficult

By W. G. THOMPSON, State Highway Engineer.

SITUATED as it is between two great manufacturing and shipping centers, and having an enormous internal vehicular traffic of its own, New Jersey's road maintenace problem is becoming increasingly difficult to handle to the satisfaction of all concerned. The unusual requirements of crushed stone, sand, cement, and bituminous products by the Federal Government for its war work, and by contractors on buildings, etc., directly or indirectly required for war purposes, has placed all such materials at a premium, while the great increase in the use of the highways has made greater than ever the need for better pavements and for the maintenance and repair of those we now have.

The combination of continuous heavy trucking and heaving due to frost expansion during the past winter ruined thousands of square yards of pavement and foundation. This required in many cases that long stretches of the subfoundation be removed and the holes filled with field or crushed stone before replacing the pavement or surfacing; also the replacing of many longitudinal and cross drains which had become clogged through freezing and thus contributed to the heaving of the foundation.

POOR DRAINAGE CAUSE OF FAILURE.

Most of the serious failures of our pavements were due to inadequate drainage of the foundation, which lack is being remedied as rapidly as possible.

Maintenance of macadam pavement presents the most serious problem, and although these are being replaced rapidly by more durable surfaces, there are hundreds of miles to be repaired each year. The method found most satisfactory is to give the surface a light coat of tar, after which there is spread upon it sufficient sand to take up the tar, thus forming a carpet coat which presents an agreeable riding surface and prevents the macadam top from raveling. On roads having a considerable motor traffic, this treatment must be given every year. The annual cost of maintenance of such pavements certainly emphasizes the economic wisdom of laying durable asphaltic or concrete pavements as rapidly as possible.

Many of our counties have a regularly organized patrol system, where one or two men constantly patrol a definite section of road, and have a team or light motor truck to transport the material used. Piles of half-inch stone and barrels of tar or emulsified asphalt are placed at convenient intervals along the road, and as holes or ravelings develop, stone and bitumen sufficient to fill the holes flush with the pavement surface are mixed upon a mixing board. This system is economical and satisfactory, inasmuch as it provides a smooth surface for vehicles at all times, as opposed to the old method, still in vogue in many localities, of allowing the pavement to become full of potholes before making repairs.

GRAVEL ROADS A CONSTANT CARE.

Where it is impracticable to secure for repairs the material of which any bituminous pavement is composed, temporary and satisfactory repairs are made by filling the holes with hand-mixed stone and emulsified asphalt, which if well tamped will, after it has set, maintain a good surface for months under heavy traffic.

As the southern and coastal sections of New Jersey have many seashore resorts, maintenance of the hundreds of miles of gravel roads leading to them imposes a heavy burden upon the communities involved, especially during the summer months; and constant scraping is required. This work is started immediately the frost leaves the ground in the spring and is religiously carried on after every rain. From April until freezing weather in the fall no smoother, easier surface for automobiles can be found than these gravel roads. The use of a lignin binder on several of the more heavily traveled gravel roads has, to a considerable extent, prevented raveling and wearing away of the surface and kept it intact during the winter. This is usually applied in two coats by a pressure distributor early in the summer.

Embargoes on freight shipments, the recent and proposed future increases in freight rates, together with Government requirements of stone, gravel, cement, sand, and the bituminous materials, have increased prices and made deliveries so uncertain that many communities have been unable to secure bids on extensive repairs. The establishment within this State of numerous cantonments, hospitals, loading plants, and other Government activities requiring employment of thousands of men has so reduced the supply of common labor, and the abnormal increase in wages incident to this demand has in many localities resulted in almost prohibitive costs of road maintenance; in fact, many localities are unable to secure labor or teams at any price.

$4,600,000 FOR ROADS.

The inevitable result will be rapid deterioration of pavements under the constant and rapidly increasing traffic, although the counties and townships are making every effort to meet the demand. The State has allotted $1,600,000 as aid to the counties for repairs and maintenance, to which should be added approximately $3,000,000 raised by the counties for the same purpose.

The recent decision to allow preference to shipments by rail of road materials after the necessary tonnage for coal, coke, and ore is supplied will greatly assist highway maintenance. This decision evidences the general realization of the importance of the highways as aids to commercial transportation. The State authorities hope the Federal Government will find it unnecessary to seriously curtail the use of asphaltic and tar binders, as the only effective means of preventing the destruction of hundreds of miles of macadam roads is the annual or biannual application of tar or asphaltic oil, which with sand or screenings added makes a very satisfactory carpet coat.

FEEDERS ALL IMPORTANT.

The highways must be kept in condition at any cost, and but little highway work can in these days be classed as unessential. The main routes between large cities are generally considered most important, but the feeders to these, including country roads, carry farm products to city markets, and are all important. Produce from the farms of New Jersey is carried from 30 to 75 miles by motor truck to such large cities as Philadelphia, Newark, and New York. Therefore to fail to keep the farming country roads in good condition is to invite a curtailment of production and delivery of foodstuffs.

It therefore behooves all highway officials to work in and out of season for the extension of the existing system with first-class durable pavement, and for the proper maintenance of the maximum mileage that finances and material supply will permit; and to urge a closer cooperation with the Federal Government to the end that its highways transport shall be aided and expedited to the fullest possible extent.

This will mean that in addition to keeping the pavement in good condition during summer and winter, the several States and communities provide as liberally as possible for snow removal during the winter. This is not an unmixed blessing, as the removal of snow and consequent possible distribution of traffic over the entire pavement will minimize the deterioration resulting from confining traffic to one wheel track, which is inevitable where the entire pavement width is not clear of snow.

Soil Conditions Make the Situation in Nevada Unusually Difficult to Meet

By C. C. COTTRELL, State Highway Engineer

THE small amount of money available and the hundreds of miles of roads in Nevada do not permit elaborate maintenance methods and the ones now used must appear to those unfamiliar with pioneer conditions to be very crude.

A wrong impression would be conveyed if it were that the roads of Nevada are bad; on the other hand they are good, and viewed with respect to the natural soil, climatic conditions, sparseness of settlement and lack of road finances, they are excellent.

AT TOP—NATURAL SOIL ROAD IN NEVADA, WHICH BECAUSE OF THE EXCELLENT GRAVELLY SOIL IN WHICH IT IS LOCATED REQUIRES BUT LITTLE MAINTENANCE. AT BOTTOM—ROAD ACROSS ALKALI FLAT WHICH BECAUSE OF THE SILTY SOIL IN WHICH IT IS LOCATED AND THE LONG DRY SUMMER RAPIDLY RUTS UNDER TRAFFIC. THIS ROAD HAS BEEN RELOCATED IN BETTER MATERIAL.

Generally speaking, the construction of roads in Nevada has in the past consisted merely of clearing the sagebrush, and until the last few years little attention was given to them, as their condition served the local interests passably well. With the coming of the motor vehicle, however, and its peculiar adaptation to the long hauls of Nevada, a feeling has swept the State that something must be done to improve the roads, and any public official who neglects to work in that direction is exceedingly unpopular.

The maintenance of all the roads in Nevada is at the present time in the hands of the various boards of county commissioners, and while the statutes provide different methods of doing the work in the several counties, in actual practice it is most often handled directly by, or under the immediate directions of, the county commissioners.

DRAG COMING INTO WIDER USE.

The big problem is to maintain a hard and smooth surface during the long, dry summer months and to prevent the roads from becoming muddy in the winter. The road grader, while not the best implement to use, is the device most often employed. In the early spring, while the soil is still damp, material is brought toward the center to crown the roadbed and fill up the ruts and chuck holes; very often twice over each side of the road is considered sufficient for that purpose. The drag, with its lower operating cost and its puddling effect, is just now beginning to be appreciated and used.

There are many miles of road which, because of the light traffic and the excellent gravelly nature of the material in which they are located, require little if any attention. On the other hand, there are some sections of road across low, highly alkaline flats which, because of the very silty soil in which they are located, never can be satisfactorily maintained. The only feasible improvements are either to relocate the road in better material or to surface it with gravel or crushed rock: the relocation is by far the more preferable. The small precipitation during the winter months serves to smoothen and harden the roadway in these flats. The summer traffic, however, soon cuts the surface, forming ruts and chucks, and the constant churning of the wheels turns it into a sea of fine, white-powdered alkali dust, coating everything and everybody in sight. New roads are being constructed rapidly to avoid these flats.

Loose sand is found in but comparatively short stretches and is handled either by corduroying the road with sagebrush, straw, or manure which, while effective, is but a temporary expedient, by relocating the road entirely, or by placing a clay material on top of the sand, forming a top-soil road. Suitable material for a top soil, however, is very scarce over the entire State.

BADGERS UNDERMINE WHEEL TRACK.

In some portions of the State badgers, which are very numerous, burrow holes in the wheel track of the road. It is the general opinion that this location is selected by the badger in order to secure a firm walled burrow. Under traffic these holes rapidly develop into large chucks which in the dry summer can be repaired only by filling them with gravel or shale shoveled from a wagon. To drag or grade the road at that season of the year would ruin it.

Systematic and more intelligent methods of construction and maintenance are being rapidly adopted by the various counties, and each year witnesses a big improvement in road conditions over those of the previous year.

Local organizations, such as good-roads clubs and automobile clubs, have done much to further the good-road movement and have been the means of getting large numbers of volunteer workers out on the roads on specified "good-road" days.

It requires some time and a big effort to bring roads which barely served local interests with their slow-moving horse-drawn vehicles to the condition of effectively serving the whole country with its heavily laden trucks and swift-moving automobiles, but the people of Nevada are keen to accomplish that result as soon as possible and they are doing it.

Connecticut Turns to Labor-Saving Devices and Substitute Material

By C. J. BENNETT, Highway Commissioner.

CONNECTICUT, like other States, is faced at the present time with the necessity of maintaining its roads under extremely adverse conditions. On the one hand, we have a concentrated truck and motor vehicle traffic unparalleled in the history of highway maintenance in this or any other country. On the other hand, we see a shortage of labor and the difficulty of securing materials for maintenance purposes.

It is therefore imperative for us to find a means to meet these difficulties, or our roads will deteriorate beyond hope of repair. In other words, in order to keep our work at the same standard of excellence which has been maintained heretofore, we are obliged to use methods and machinery hitherto unemployed.

The first requisite to meet this situation is additional attention on the part of the supervising agents; second, the utilization of machinery and labor-saving devices to a greater extent than in the past; and third, the securing of substitutes for material formerly used but not at present available, meaning, in case three, that local available materials must be used even though less adapted to requirements.

In a broad way, an attempt has been made first to increase the effort of the supervising agents by an appeal to their patriotism by a suggestion of necessity of work at high pressure to maintain a standard of excellence which has always been a matter of pride, and also to increase wages so as to make it more attractive for the men than in the past.

In connection with labor saving by the use of machinery, the motor truck has been utilized to a great extent in delivering material, spreading sand, gravel, and oil, and transporting gangs of men from one point to another at high speed. Advantage has been taken of mechanical loaders for gravel and sand, doing away with hand shoveling so far as is possible. Mechanical spreaders for sand and gravel to cover oil or other bituminous material have been utilized where possible. In fact, wherever it is feasible to substitute any machine, in such a manner as to save labor, it has been done even at a money loss. The department has also purchased a great amount of equipment so that local material can be quickly utilized. Such equipment consists of stone crushers, gravel screens, and machinery of a like nature.

As a result of this effort we hope, with considerable optimism, that the highways in this State will be kept to a standard equal to that heretofore set.

Idaho Economizes Effectively Through the Use of Motor Trucks

By H. C. ALLEN, State Highway Engineer.

THE maintenance work done on the Idaho State highways during the past 12 months has been rather difficult, and some of it ineffective, largely on account of the dry season in 1917 and the beginning of 1918. The light volcanic ash soil prevailing in the southern portions of the State pulverizes readily under traffic, and no amount of labor will produce a firm road surface in its dry condition.

During the latter part of last season two auto sprinkling trucks of 1,000-gallon-tank capacity were put to work in the Twin Falls and Pocatello districts on unsurfaced roads. Many places were practically impassable from deep dust and chuck holes. The application of water soon began to bring them to a firmer condition, and doubtless was the means of saving the roads in that section from very serious impairment.

The first work of the present season consisted largely of reshaping with engine graders, the ordinary three-way drag being used to considerable extent on both dirt and gravel surfaced roads after rains. The urgent demand for teams on agricultural work has caused some roads to be unduly neglected and quite a good deal of dragging has been done with trucks. This method is proving economical and effective.

Last year's experience with auto sprinkling, with a light-drag attachment, demonstrated the economy and effectiveness of that form of maintenance. The sprinklers are again being put into service while the road surface is yet in good shape and it is confidently expected that it will be so maintained.

A considerable portion of Idaho highways are of such natural material that once being put in good shape in the spring, they will stand up well for the summer under ordinary traffic. The correct shaping of road sections in the fall to permit them to go into the winter properly is accomplished with drags and some grader work. All of which work it is our purpose to do largely by mechanical means.

With the increase of auto-truck traffic our problems are increasing and the large one now to be met is to provide funds from the sources responsible for the rapid deterioration of road surfaces. The primary object of auto tax should be to maintain already constructed roads. In Idaho, 75 per cent of such tax goes to the counties, and the remaining 25 per cent to the State highway department. Almost one-fourth of the State's share is used for auto number plates, registration and a certain interest fund, leaving only about one dollar in five of the original tax collected to be spent on trunk road maintenance. The auto tax moneys in the hands of the counties is put into road and bridge funds and spent at the discretion of the county commissioners, usually in an ill-advised and ineffective manner.

A better distribution of existing revenues and more effective application to road maintenance will be of great benefit to the State. Legislation in that direction will be promoted at the next session of the legislature, in 1919.

STATE HIGHWAY MANAGEMENT, CONTROL AND PROCEDURE.

A bulletin has just been completed in the Bureau of Public Roads dealing with the organization, powers, and duties of State highway departments; classification, control, and procedure in the construction and maintenance of roads to which the States contribute the whole or a portion of the cost; the origin of State road funds and the purposes to which those funds are applied.

It has been decided to publish the bulletin as a serial in "Public Roads," beginning with the August number. It contains a chapter for each State, in which the following subjects are treated: Development and results of State participation and control of road work; organization, powers, and duties of highway departments, including personnel of State and local forces; classification of roads to which the State contributes a portion or the whole cost, including the methods of selection of such roads, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by State and local authorities in superintending construction and maintenance; sources of State road funds, purposes to which those funds are applied, basis of allotment and apportionment of such funds, and amounts applied to the various purposes for the latest fiscal or calendar year.

Each State chapter will be accompanied by a chart showing the organization, personnel, and lines of responsibility of the State and local road officials, and the relations existing between them.

The State chapters have been summarized and analyzed and the results will appear in the form of tables, charts, and text so arranged as to enable the reader to obtain a comprehensive knowledge of the whole study without having to refer to the various State chapters except for details. This part of the bulletin deals with the history and present trend of State aid and State highway control; the organization of highway departments and the control exercised by those departments; the classification and control of State and State aid roads; and the sources, control, and disposition of State road funds.

The bulletin was prepared by M. O. Eldridge, assistant in road economics; G. C. Clark, and A. L. Luedke, engineer economists.

$280,000,000 PUT INTO HIGHWAYS AND BRIDGES BY STATES IN 1917

Prepared in the MANAGEMENT BRANCH, BUREAU OF PUBLIC ROADS, by ANDREW P. ANDERSON, Highway Engineer.

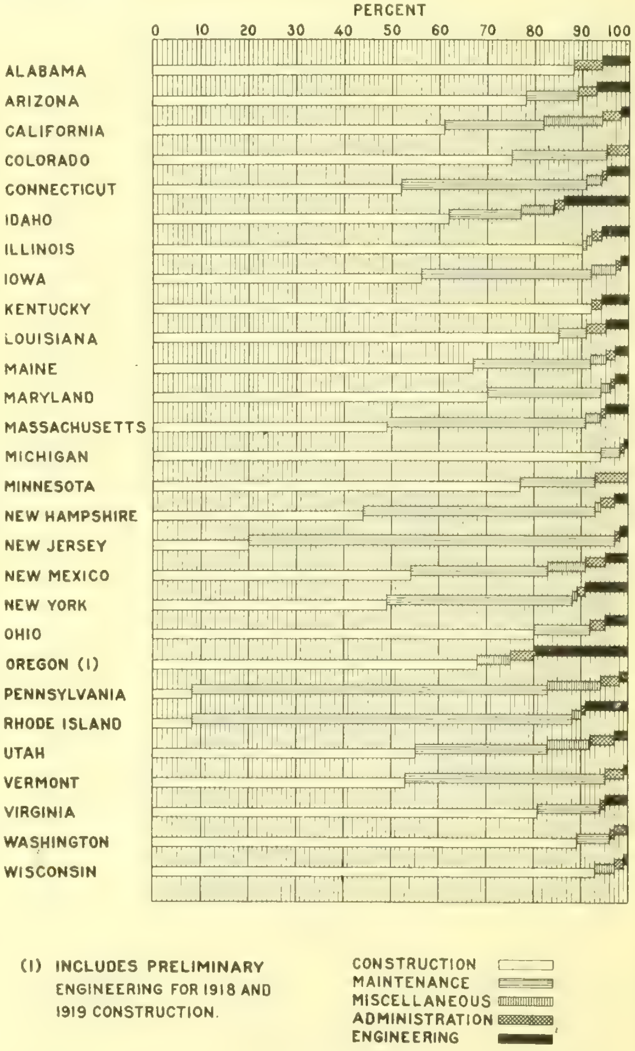
CASH expenditures on rural roads and bridges in the United States in 1917 amounted to $279,915,332. To this should be added the value of statute and convict labor, which can not be fixed to any great degree of accuracy but probably amount to not less than $15,000,000, thus making the grand total expenditure for the year $295,000,000. This total is made up of the actual expenditure of such items as labor, materials, supervision, and administration directly connected with the construction, improvement, and upkeep of our public roads and bridges, and does not include interest on bonds and other outstanding obligations.

This, however, does not represent the total outlay by the States and communities because of their rural public roads. At the present time there are outstanding more than $400,000,000 in road and bridge bonds and long-term warrants maturing at the rate of about $20,000,000 per year and requiring about an equal amount annually for the payment of interest charges.

The full extent of this bond burden, however, is impossible of any exact determination. For a number of years past road and bridge bonds have been issued at the rate of about $40,000,000 pre annum, and while there is apparently a slight decrease in the amount issued or sold during 1917, there seems to have been no decided decrease in the amount of such bonds voted or authorized. Moreover, the bonds actually designated for road and bridge purposes do not represent the full extent of the burden. General bonds are issued in many cases to cover actual or threatened deficits occasioned wholly or in part by road and bridge expenditures. Furthermore, outstanding road and bridge bonds or warrants are often taken up by general refunding bonds and their identity as pertaining to road work thus entirely lost. Such data as available, however, serve to call attention to the abuses to which the bond method of financing often is subjected. To issue bonds for the financing of road improvements frequently is both advisable and necessary. But this does not justify much of the present-day practice. Millions of dollars' worth of road bonds having a term of 30 years or more are still issued every year for the payment of improvements which can not possibly last one-half of the term of the bonds and in many cases will actually not last one-third of the time.

MOVEMENT TO LIMIT BOND-TERM GAINS.

The movement to limit the term of road bonds so as to make the term fall within the life of the improvement seems to be gaining ground gradually. However, only a few States have as yet embodied these requirements in definite workable legislation. Perhaps the best examples of such legislation are found in New Jersey and Wisconsin.



(1) INCLUDES PRELIMINARY ENGINEERING FOR 1918 AND 1919 CONSTRUCTION.

In New Jersey the attempt is made to limit the time in accordance with the class of construction while in Wisconsin the same effort is made on the basis that the State highway construction is naturally of a higher character than the requirements for town roads and will therefore have a longer life.

New Jersey (ch. 240, Laws 1917) provides that the term of bonds for constructing or reconstructing the pavement of roads, streets, or highways, or widening such pavements shall not exceed the probable period of the usefulness of such improvement and in any case the term shall not exceed the following:

If constructed of sand and gravel, 5 years; if constructed of water-bound macadam or bituminous macadam by the penetration method, 10 years; if constructed of bituminous concrete, 15 years; if constructed of blocks of any material or sheet asphalt laid on a concrete foundation, 20 years; if constructed of concrete not less than 6 inches thick, 20 years; if for the acquisition of land for roads, streets, or highways, 30 years.

Wisconsin (chs. 174, 465, and 500, Laws 1917) provides that for town and county bonds to defray the cost of town and county road improvements the bonds shall not have a term in excess of 10 years, while the term of county bonds for the improvement of roads on the State-trunk line system shall not exceed 20 years.

TABLE I.—EXPENDITURES DURING THE YEAR 1917 BY OR UNDER THE SUPERVISION OF THE STATE HIGHWAY DEPARTMENTS.

State.	Funds.			Distribution of expenditure.						State funds available 1918 (approximate).	Total road and bridge expenditures 1917, not under State highway department (approximate).
				Construction.							
	State.	Local.	Total.	Roads.	Bridges.	Maintenance, roads and bridges.	Engineering.	Administration.	Equipment and miscellaneous.		
Alabama	$89,511	$79,511	$169,021.78	$131,530	$17,643	....	$9,849	$10,000	....	$154,000	$2,700,000
Arizona	543,422	....	543,422.41	289,353	136,856	857,288	10,500	19,426	....	1,000,000	1,026,000
Arkansas	80,262	1,545,000	1,625,262.17	1,345,000	200,000	....	80,262	(1)		300,000	1,710,000
California	3,058,030	128,170	3,186,200.00	1,918,740	(2)	687,100	79,000	129,870	[3] $371,490	2,500,000	[4] 15,059,000
Colorado	703,000	767,000	1,470,000.00	862,000	[5] 270,000	270,000	....	68,000	....	900,000	1,100,000
Connecticut	2,197,264	330,962	2,528,225.49	[6] 1,029,410	271,260	991,402	115,058	22,778	65,317	3,600,000	1,476,000
Delaware [7]	21,600	....	21,600.00	....	....	1,286	9,029	5,775	5,510	200,000	300,000
Florida	23,797	....	23,797.39	....	....	....	12,036	7,207	4,554	200,000	6,361,000
Georgia	1,910	16,440	18,350.00	9,500	500	....	7,450	900	....	10,000	4,300,000
Idaho	473,132	369,591	842,723.00	391,676	134,219	126,806	115,732	19,157	55,1[illegible]	600,000	1,250,000
Illinois	1,258,338	1,810,390	3,068,728.42	2,735,935	46,683	40,503	166,075	60,000	19,534	2,000,000	7,015,000
Indiana	14,000	....	14,000.43	2,539	....	....	2,360	6,904	2,197	1,050,000	14,000,000
Iowa	89,787	15,535,619	15,625,406.22	2,506,241	[5] 6,223,637	5,685,781	[8] 370,114	89,787	719,817	700,000	....
Kansas [7]	10,000	....	10,000.00	....	....	....	(9)	10,000	....	25,000	6,000,000
Kentucky	1,501,650	1,422,000	2,923,651.00	2,844,002	(2)	....	46,049	23,600	10,000	950,000	2,000,000
Louisiana	182,295	358,681	540,976.02	430,708	35,984	9,841	42,107	20,060	2,276	200,000	3,000,000
Maine	1,112,675	632,308	1,744,982.04	1,019,755	150,973	438,676	53,693	37,734	41,154	1,000,000	1,500,000
Maryland	2,804,707	278,975	3,083,681.94	1,857,549	387,065	730,652	80,110	26,313	1,993	3,000,000	3,000,000
Massachusetts	4,231,802	601,000	4,832,802.00	2,261,354	78,195	2,090,000	281,891	57,339	111,023	1,000,000	4,662,000
Michigan	1,704,359	3,968,794	5,673,153.00	5,125,224	187,751	247,178	62,000	43,000	8,000	2,000,000	5,517,000
Minnesota	1,429,865	2,722,895	4,152,759.51	2,290,541	[11] 922,346	672,039	267,834	(1)	....	1,600,000	3,872,000
Mississippi	6,500	....	6,500.00	....	....	....	(9)	6,500	....	6,500	3,250,000
Missouri [7]	367,913	7,021	374,933.38	190,645	....	148,068	7,735	12,038	16,447	1,250,000	7,000,000
Montana [1]	25,729	239,140	264,869.34	15,500	223,640	....	19,671	6,058	....	150,000	5,092,000
Nebraska [7]	[12] 9,500	93,900	103,400.00	....	94,000	4,200	5,200	(12)	....	150,000	4,500,000
Nevada [7]	36,796	....	36,795.85	....	....	....	16,766	20,030	....	300,000	200,000
New Hampshire	589,254	449,451	1,038,704.78	448,002	....	505,014	26,608	27,634	31,448	650,000	1,200,000
New Jersey	1,501,902	2,778,995	4,280,897.40	758,049	56,023	3,302,333	85,834	59,271	19,788	5,500,000	2,000,000
New Mexico	280,578	265,289	545,867.40	233,526	60,000	159,800	28,419	20,912	13,210	250,000	200,000
New York	9,432,679	2,282,452	[13] 11,715,130.65	5,635,027	....	4,537,709	1,108,622	273,874	159,899	14,000,000	[14] 9,970,000
North Carolina [15]	20,000	....	20,000.00	....	....	....	(9)	20,000	....	300,000	5,500,000
North Dakota [1]	28,638	1,341	29,979.26	[10] 1,676	....	....	23,260	5,043	....	250,000	2,838,000
Ohio	2,835,649	2,181,456	5,017,104.49	3,171,895	288,117	1,145,886	239,576	116,669	54,961	1,000,000	7,000,000
Oklahoma	286,922	2,888,433	3,175,355.25	374,653	1,486,525	705,136	147,684	12,715	148,642	1,750,000	547,000
Oregon	711,000	....	711,000.28	475,418	9,172	....	113,639	34,131	18,641	1,500,000	5,000,000
Pennsylvania	4,351,566	111,768	4,463,333.19	251,959	80,445	3,347,906	75,318	206,121	[16] 501,584	6,000,000	7,000,000
Rhode Island	486,725	....	486,724.84	....	40,262	387,116	43,054	5,000	11,293	750,000	375,000
South Carolina [7]	27,161	....	27,160.75	....	....	....	8,500	3,500	15,161	25,000	1,250,000
South Dakota [17]	5,000	....	5,000.00	....	....	....	(9)	5,000	....	100,000	2,750,000
Tennessee	231,500	50,000	281,500.00	....	....	250,000	9,800	21,700	....	1,100,000	2,200,000
Texas [17]	10,000	....	10,000.00	....	....	....	7,000	3,000	....	600,000	10,000,000
Utah	120,200	822,929	943,129.44	471,553	48,393	264,538	33,428	44,043	81,175	750,000	950,000
Vermont	578,883	376,606	955,489.01	466,881	45,114	402,010	2,472	39,013	....	600,000	725,000
Virginia	695,171	1,641,608	2,336,778.74	1,754,243	144,102	298,868	109,165	20,896	9,505	1,400,000	1,800,000
Washington	2,031,392	92,299	2,123,690.53	1,896,821	(2)	[18] 138,596	61,883	26,391	....	3,500,000	4,992,000
West Virginia [17]	....	2,700,000	2,700,000.00	2,400,000	300,000	....	....	....	....	350,000	5,500,000
Wisconsin	1,050,888	3,335,666	4,386,554.00	3,650,560	431,206	....	[19] 61,919	77,869	[19] 165,000	2,430,000	5,500,000
Wyoming [7]	37,845	2,846	40,690.65	673	5,992	....	24,052	9,144	529	70,000	549,000
Total and average	17,290,796	50,888,536	98,179,332.11	49,248,138	[20] 12,376,103	27,648,732	[20] 4,110,784	[20] 1,734,702	3,060,881	74,120,500	181,736,000

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[1] Included under engineering.
[2] Included under roads.
[3] Consists largely of engineering for future construction.
[4] Does not include San Francisco County.
[5] Includes culverts.
[6] Includes $80,085.34 for elimination of dangerous conditions on trunk line highway.
[7] State Highway Department organized during year.
[8] By counties.
[9] Included under administration.
[10] Estimated; exact data not obtainable.
[11] Includes 415 culverts.
[12] Remainder not segregated from expenditures of irrigation department.
[13] State and county highways only.
[14] Town highways and bridges, includes $2,664,000 of State funds.
[15] Does not include $58,945.43 of local funds expended under supervision of State engineer's office.
[16] Includes $256,188 for the purchase of turnpikes and about $150,000 for operating the expenses of office and traveling expenses.
[17] Complete data not available.
[18] To June 15, 1917, only.
[19] County supervision.
[20] Partial totals.

The expenditures on our city, town, and village streets are not included in these compilations, as no complete records are available as to their amounts. However, from the available data the expenditures on account of our streets are estimated to amount in round numbers to $300,000,000 annually. With the present tremendous development of motor-truck and automobile traffic the city, town, and village streets have become an integral part of our road system and a vital factor in the efficient operation of almost any general system of motor hauling and especially those involving the delivery of country produce. It is, therefore, hoped that more definite data in regard to the extent, cost, and conditions of our streets may soon be available.

TABLE II.—ROAD MILEAGE.

State.	Work done in 1917 under State supervision.			Total all State and State-aid roads built to Jan. 1, 1918.	Mileage of rural public roads.		
	State and State-aid roads built	Roads maintained with State aid, 1917.	Number of bridges built by State or State aid, 1917.		Total all surfaced roads in State (approximate).	Total all public rural roads in State.	Percentage of surfaced roads in State.
	Miles.	*Miles.*					
Alabama	[1] 67		3	726	6,050	55,446	10.9
Arizona	[2] 50	270	8	422	425	12,075	3.5
Arkansas	225		10	759	1,725	50,743	3.4
California	313	2,213	17	2,220	12,800	61,039	20.9
Colorado	[3] 1,120	4,000	[4] 145	[5] 8,425	2,500	39,780	6.3
Connecticut	59	1,457	8	[6] 1,686	3,160	14,061	22.4
Delaware		19		160	300	3,674	8.2
Florida					3,800	17,995	21.1
Georgia	[7] 7		2	7	13,200	80,669	16.4
Idaho	[7] 75	451	76	488	825	24,396	3.4
Illinois	[8] 470	449	88	1,237	12,750	95,647	13.3
Indiana					31,000	73,347	42.5
Iowa	[9] 1,332	109,000	[10] 45,000	1,338	1,400	104,074	1.3
Kansas					1,500	111,052	1.3
Kentucky	[24] 698			2,000	13,900	57,916	24.0
Louisiana	83	500		837	2,700	24,563	11.0
Maine	170	3,750	[12] 19	1,968	3,420	23,537	14.5
Maryland	96	1,189	6	1,400	3,000	16,459	18.2
Massachusetts	[13] 158	1,559	24	2,094	9,050	18,681	47.5
Michigan	1,053	3,940	24	4,993	10,600	74,190	14.3
Minnesota	[14] 1,984	11,439	[15] 749	11,995	6,900	93,517	7.4
Mississippi					2,700	45,779	5.9
Missouri	28	11,361		(16)	7,500	96,041	7.8
Montana	29		38	59	850	39,204	2.2
Nebraska			6		1,400	80,272	1.8
Nevada					340	12,182	2.8
New Hampshire	[17] 82	1,388		1,362	1,975	14,020	14.1
New Jersey	66	2,500	4	2,120	6,050	14,817	41.0
New Mexico	75	2,200	21	921	600	11,873	5.0
New York	410	6,639	[18] 679	7,175	18,400	79,398	23.2
North Carolina					6,850	50,758	13.5
North Dakota	7			7	1,150	68,796	1.7
Ohio	289	2,053	850	1,650	31,800	86,354	36.8
Oklahoma	[19] 794	2,153	[10] 1,904	2,694	500	107,916	.5
Oregon [11]	75			488	4,950	36,819	13.4
Pennsylvania	[20] 10	8,844	83	2,000	10,600	91,556	11.6
Rhode Island		325	7	325	750	2,170	34.5
South Carolina					3,800	42,226	9.0
South Dakota					800	96,306	.8
Tennessee		3,200		150	8,875	46,050	19.2
Texas					12,100	128,960	9.4
Utah	[21] 200	3,000	40	3,640	1,550	8,810	17.5
Vermont	116	4,339	64	2,127	2,220	14,249	15.7
Virginia	[22] 523	2,153	47	4,986	5,900	53,388	11.0
Washington	324			2,301	6,225	42,428	14.7
West Virginia	(16)	(16)			1,600	32,024	5.0
Wisconsin	[23] 1,000		231	6,070	15,250	77,280	19.8
Wyoming	7		8	7	550	14,797	3.8
Total and average	11,996	181,391	50,161	80,933	296,290	2,457,334	12.0

[1] Includes 25 miles of earth roads.
[2] Includes 16 miles of earth roads.
[3] Includes 1,000 miles of earth roads.
[4] Also 1,300 culverts.
[5] Includes about 6,500 miles of earth roads.
[6] Includes about 200 miles of reconstruction.
[7] All earth roads.
[8] Includes 174 miles of earth roads.
[9] Includes 921 miles of earth roads.
[10] Includes culverts.
[11] Estimated, exact data not obtainable.
[12] 11 not completed.
[13] Includes 6 miles of earth roads.
[14] Includes 1,570 miles of earth roads.
[15] Includes 415 culverts.
[16] No data.
[17] Includes 13 miles of earth roads.
[18] Town bridges.
[19] Includes 549 miles of earth roads.
[20] Also 199 miles resurfaced.
[21] Includes 150 miles of earth roads.
[22] Also 129 miles of reconstruction. Includes 90 miles of earth roads.
[23] Includes 527 miles of earth roads.
[24] Includes 132 miles of earth roads.

EFFECT OF PRESENT CONDITIONS ON WORK.

Present abnormal conditions are having a decided effect on road and bridge work. From 1904 to 1916 the average annual increase in the total rural road and bridge expenditures was about 10 per cent over and above those of each previous year. During the years 1916 and 1917, however, this increase was reduced to about 2 and 3 per cent, respectively. This, however, does not signify any general decline in road work. On the other hand, the reverse is true. The expenditures by or under the control or supervision of the several State highway departments have steadily continued to increase. Thus, while the total amount of funds expended by or under the supervision of the State highway departments in 1917 exceeded those of 1916 by more than 30 per cent, the total expenditure of strictly local funds by the local communities during the same period decreased 10 per cent.

The amount of State funds devoted to road and bridge work continue to show a large annual increase. In 1904 eleven State highway departments expended a total of $2,550,000 for road and bridge work, and in 1914 thirty-one State highway departments expended $24,221,000, while in 1917 every State in the Union made some contribution to this work which amounted to a grand total of $47,291,000 of State funds as distinguished from local funds. Furthermore, the utilization of convict labor in road work or the preparation of road materials under competent State supervision is coming to be a more and more important factor, while the employment of statute labor or working out the road and poll taxes is decreasing from year to year. In one-half of our States the use of convict labor in road work under State direction or control has definitely passed what may be called the experimental stage and proved a success.

TABLE III.—CASH ROAD AND BRIDGE EXPENDITURES FOR THE CALENDAR YEARS 1904, 1914, 1916, AND 1917.

State.	Year in which first State-aid law passed.	State funds expended by or under State highway department.				Total State funds expended for road work from passage of law to Jan. 1, 1918.	Total cash expenditure from all sources. (Approximate.)			
		1904	1914	1916	1917		1904	1914	1916	1917
Alabama	1911	....	$170,232	$102,422	$89,511	$778,338	$378,040	$3,949,019	$4,186,384	$2,669,022
Arizona	1909	....	....	441,202	543,422	2,024,012	67,591	982,721	1,988,221	1,569,422
Arkansas	1913	....	115,000	55,483	80,262	300,745	681,934	1,522,696	3,443,887	3,335,262
California	1895	$11,251	....	4,285,964	3,058,030	23,915,085	2,157,396	19,171,985	20,392,434	18,245,200
Colorado	1909	....	301,274	607,628	703,000	2,335,379	635,395	1,937,546	2,313,208	2,570,000
Connecticut	1895	219,165	1,307,381	1,865,948	2,197,264	20,592,791	1,195,125	3,640,963	3,200,948	4,004,225
Delaware	1903	14,000	31,000	31,000	21,600	277,295	90,803	511,628	512,000	321,600
Florida	1915	....	....	10,484	23,797	35,416	437,184	2,280,255	4,010,484	6,384,797
Georgia	1908	....	....	....	1,910	1,910	894,936	3,688,172	3,750,000	4,318,350
Idaho	1905	....	49,812	100,057	473,132	1,146,001	201,648	1,371,469	1,948,118	2,092,723
Illinois	1905	....	387,989	1,119,202	1,258,338	4,064,167	3,844,424	8,734,713	10,356,669	10,083,728
Indiana	1917	....	....	....	14,000	14,000	3,438,389	14,233,986	13,500,000	14,014,000
Iowa	1904	....	74,000	90,821	89,787	436,543	2,344,107	10,187,507	14,427,877	15,625,406
Kansas	1911	....	9,080	10,000	10,000	50,000	692,823	5,544,048	5,610,000	6,010,000
Kentucky	1912	....	18,000	708,346	1,501,650	2,826,711	1,161,194	2,474,621	4,448,533	4,923,651
Louisiana	1910	....	161,186	184,533	182,295	973,155	345,452	1,777,572	3,458,643	3,540,976
Maine	1901	44,885	467,149	1,055,250	1,112,675	8,033,134	1,472,393	2,042,007	3,167,215	3,244,982
Maryland	1898	....	356,845	2,280,000	2,804,707	22,667,849	873,471	6,000,052	5,560,000	6,083,682
Massachusetts	1892	575,606	242,560	2,701,236	4,231,802	25,933,030	2,871,222	6,091,875	6,499,141	9,494,802
Michigan	1905	....	657,264	982,939	1,704,359	5,869,999	1,816,504	9,261,998	10,082,939	11,190,153
Minnesota	1905	....	1,309,956	1,390,525	1,429,865	7,108,564	1,607,417	6,458,940	8,742,278	8,024,760
Mississippi	1915	....	....	6,500	6,500	13,000	339,669	3,960,377	3,256,500	3,256,500
Missouri	1907	....	277,253	482,860	367,913	2,641,945	1,570,801	5,513,049	7,982,860	7,374,933
Montana	1913	....	13,516	26,150	25,729	86,225	308,744	2,888,400	3,475,569	3,356,869
Nebraska	1911	....	....	110,000	9,500	497,350	494,886	1,796,278	4,500,000	4,603,400
Nevada	1911	....	....	....	36,796	56,796	46,876	245,014	275,000	336,796
New Hampshire	1903	44,000	491,520	414,669	589,254	4,263,712	872,606	1,590,464	2,045,410	2,238,705
New Jersey	1891	250,000	1,306,596	1,167,843	1,501,902	11,025,321	3,274,811	7,208,287	5,784,354	6,280,897
New Mexico	1909	....	115,732	385,684	280,578	1,329,217	35,458	556,399	828,952	845,867
New York	1898	1,056,460	8,544,126	9,409,655	9,432,679	115,464,832	3,937,739	23,231,964	19,901,391	21,685,131
North Carolina	1901	....	5,000	10,000	20,000	68,500	624,381	5,215,491	5,510,000	5,520,000
North Dakota	1909	....	....	....	28,638	28,638	456,130	2,402,384	2,711,295	2,867,979
Ohio	1904	....	1,855,338	2,885,071	2,835,649	17,394,548	4,776,318	14,334,246	12,992,625	12,017,104
Oklahoma	1911	....	....	300,000	286,922	617,245	447,320	2,112,681	3,625,000	3,722,355
Oregon	1913	....	10,697	165,662	711,000	1,295,637	649,718	5,310,467	5,955,662	5,711,000
Pennsylvania	1903	127,767	1,976,768	3,663,352	4,351,566	38,816,129	4,887,266	10,424,580	34,464,563	11,463,333
Rhode Island	1902	79,397	....	543,152	486,725	4,937,661	376,812	446,496	943,152	861,725
South Carolina	1917	....	....	....	27,161	27,161	334,082	1,024,480	1,250,000	1,277,161
South Dakota	1911	....	....	....	5,000	5,000	268,723	1,217,809	2,708,000	2,755,000
Tennessee	1915	....	....	200,000	231,500	435,000	629,141	2,370,560	4,600,000	2,481,500
Texas	1917	....	....	....	10,000	10,000	2,543,613	9,920,079	10,500,000	10,010,000
Utah	1909	....	157,732	179,400	120,200	1,109,332	158,286	803,071	1,855,160	1,893,129
Vermont	1898	127,381	458,456	632,800	578,883	4,883,247	567,397	1,023,941	1,607,800	1,680,489
Virginia	1906	....	523,578	542,524	695,171	3,951,245	687,751	3,224,529	3,691,249	4,136,779
Washington	1905	....	1,343,431	859,672	2,031,392	10,443,853	1,344,842	7,944,717	7,518,343	7,115,691
West Virginia	1909	....	....	10,967	....	[1] 141,945	587,870	2,483,747	5,510,967	8,200,000
Wisconsin	1911	....	1,482,379	950,000	1,050,888	6,219,889	1,924,026	9,880,240	10,570,764	9,886,754
Wyoming	1911	....	....	....	37,845	81,082	74,476	669,661	150,000	589,691
Total		2,549,850	24,220,850	40,969,001	47,290,796	355,228,634	59,427,180	240,263,784	272,631,424	279,915,332

[1] Of this $118,000 was returned to the counties in 1911 by act of legislature.

One of the most notable features in the increase in the amount of funds expended under the supervision or control of the several State highway departments is that relating to maintenance. In 1914 the several State highway departments directed the expenditure of $16,343,000 for maintenance. In 1916 this had increased to $18,453,000, while in 1917 it had grown to $27,648,732. This increase is in part due to the heavier traffic and the rising prices of labor and materials, but more largely to the growing tendency to centralize the control of all our important highway work under competent State control or supervision.

On the other hand, the ever-increasing demands on our roads by the present-day traffic are compelling more substantial improvements as well as better maintenance methods, regardless of price and conditions. The reasons for these increasing traffic demands are readily apparent. At the present time approximately 5,000,000 motor vehicles, of which about 10 per cent are motor trucks or commercial vehicles, are used on our public roads and streets. These motor vehicles represent a maximum potential traffic capacity of certainly not less than 1,000,000,000 vehicle miles per day and a total horsepower of at least 120,000,000. Fifteen years ago all traffic on our roads may be said to have been horse-drawn. To-day, in addition to the horse-drawn traffic, which is probably nearly as large as ever except in regard to pleasure vehicles, we have this enormous motor vehicle traffic. Even in such a representative agricultural State as Iowa the average of 7-day counts recently made by the Iowa State highway commission and Iowa State College (at 47 stations in 17 counties) showed that the horse-drawn traffic formed less than 14 per cent of the total. It can, therefore, readily be seen why the traffic demands on the roads of to-day are so much greater than those of a few years ago.

The public rural roads of the United States at the present time have a total length of 2,457,334 miles, of which about 296,290 miles or 12 per cent are improved with some form of surfacing. The mileage of hard surfaced roads has for a number of years been increasing at the rate of about 15,000 miles per annum. During 1917 it is estimated that this mileage was somewhat reduced, amounting to about 14,000 miles. Of this mileage about 7,000 miles were surfaced under state supervision and also about 5,000 miles were improved by grading or otherwise. Thus, of the actual road construction work of a more or less permanent nature in the United States last year, more than one-half was directly under competent State supervision. In addition to this work of construction the several State highway departments also supervised the maintemance of 181,000 miles, most of which were main and truck line highways.

The expenditures for 1917 by or under the various State highway departments are shown in table 1 and the work accomplished is shown in table 2. Table 3 shows the expenditures of State and local funds for the years 1904, 1914, 1916, and 1917. Figure 1 shows the distribution of the 1917 expenditures for construction, maintenance, engineering, administration, and miscellaneous items. The variations especially in the items of administration and engineering as shown in figure 1 probably are due more to differences in bookkeeping and definition of what items should be included under these heads than any other casuse. There is great need for a common standard so that these items for the several States may be fairly comparable. At present no comparison is possible without an exhaustive study to determine just exactly what items are included in each case.

These compilations include no expenditures from Federal funds under the Federal aid road act. Only a relatively small amount of Federal aid road work was completed during 1917, and this, together with all obligations entered into under this act, are fully described in volume 1, May, 1918, of Public Roads. Neither do these compilations contain any of the expenditures for road and street work by the War or Navy Departments in or at cantonments, military reservations, training stations, and similar places.

LOWER 36-FOOT CONCRETE BRIDGE TO REMEDY SUBSIDENCE.

By HARRY C. FISHER, Chief Engineer, Mobile County, Ala.

Cedar Point Road leads south from Mobile, Ala., a short distance from and parallel to the shore of Mobile Bay. It crosses several marshes, subject to tidal overflow, with soil a semiliquid mud, in which there is an accumulation of decomposing marsh grass. The roots of this grass form a mattress that in most places will sustain the weight of a man, but when this crust or mattress is penetrated, a very unstable condition of the soil is encountered, which extends to considerable depth.

When Cedar Point Road was reconstructed and hard surfaced in 1913, the county decided to construct a concrete bridge over Perch Creek, which flows through one of the above-described marshes. The bridge is of the I-beam slab type, and a 36-foot span. The foundation was secured by driving twenty-two 50-foot piling under each pier. The piling were cut off 3 feet below mean low water, upon which was placed a double grillage constructed of 12 by 12 inch timbers. Upon this grillage the concrete piers were constructed.

A pile driver with a 3,500-pound drop hammer was used to drive the piling. When the hammer hit the piles placed in the leads, they would slip through the soft mud to considerable and varying depths. In fact, no firm foundation was encountered, as the piles were going freely when driven their entire length. However, after the piles were left standing for any length of time it would take a considerable blow from the hammer to move them.

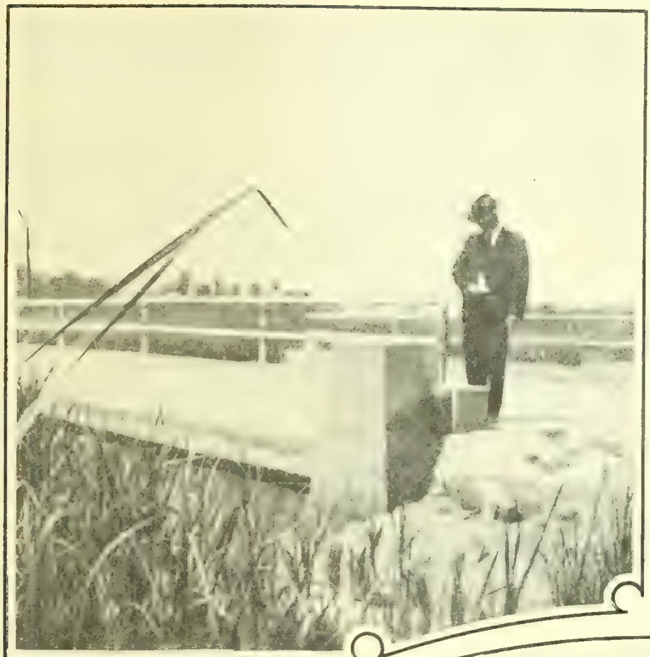
When completed, the floor of the bridge was approximately 5 feet above the general elevation of the marsh.

From the time the bridge and approaching fill were completed trouble was experienced with the subsidence of the fill, and the resulting pressure caused the wing walls to fracture at their junction with the pier. This fracture opened up more and more until eventually one of the wing walls was standing off a foot from the pier. The piers also fractured horizontally along the bottom of the floor system, and on each pier this fracture eventually opened up 3 inches on the outside of the pier.

After repeated attempts to keep the fill to grade, and finding that subsidence always occurred after new material was placed on the fill, it was decided in the latter part of 1917 to lower the bridge. As enough of the grillage extended beyond the concrete pier to support jackscrews, eight were placed under the floor system on one end of the bridge and the pier relieved of the weight of the bridge. The concrete pier was then chipped off about 3 feet and the floor system securely blocked up with heavy timbers and the jacks removed to the other end, and the operation repeated. The bridge was then lowered to its present elevation and all joints closed with grout.

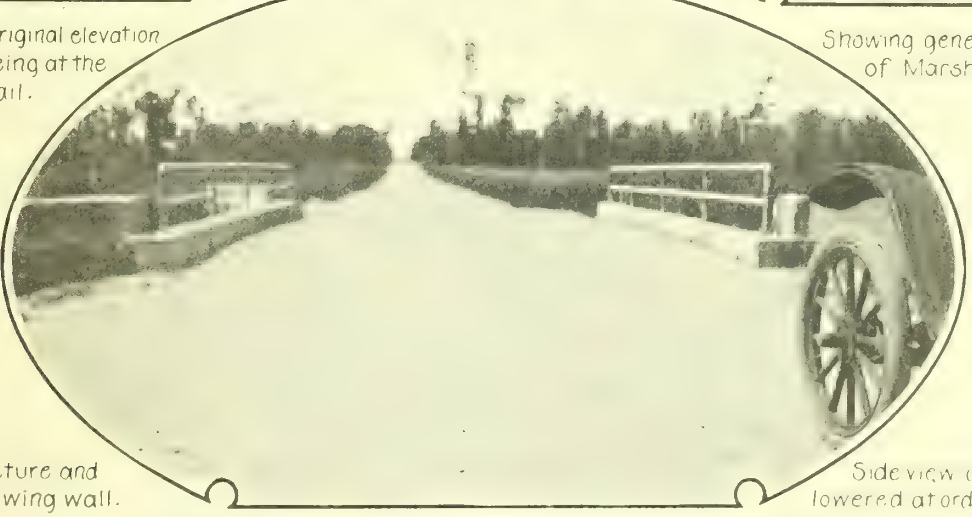
The fill was removed to the new grade, and all subsidence and movement of the wing walls and piers seems to have ceased since the weight of the fill has been removed. The fill over the marsh is constructed on a mattress of logs.

All of the work had to be done when north winds prevailed, thus bringing the tide to a very low stage.

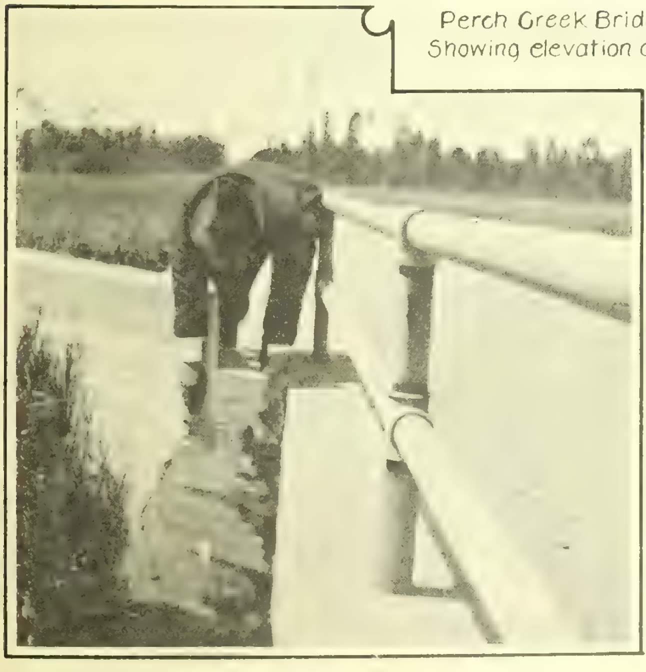


Showing the original elevation of the floor; being at the top of hand rail.

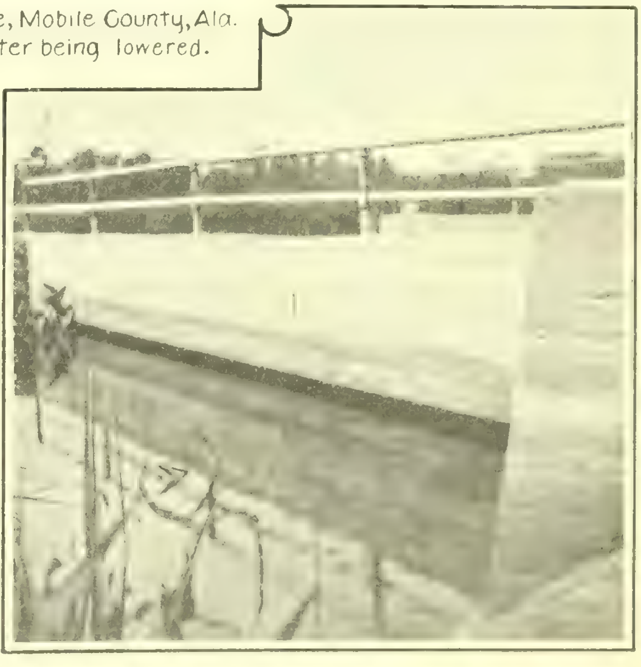
Showing general elevation of Marsh.



Perch Creek Bridge, Mobile County, Ala.
Showing elevation after being lowered.



Showing fracture and movement of wing wall.



Side view after being lowered at ordinary low tide.

DRAINAGE INCREASINGLY VITAL WITH GROWTH IN HEAVY TRAFFIC

By E. W. JAMES, General Inspector, Bureau of Public Roads

DURING the past 20 years the principal development in highway engineering has been in designing surfaces to meet the conditions imposed by a rapidly growing automobile traffic. The subject of drainage has received only such attention as engineers have been forced to give it, usually after the fact, to remedy failures in pavements resulting largely from foundation weakness more or less directly attributable to faulty drainage conditions left uncorrected at the time of original construction.

Not infrequently a far-seeing engineer intending to take proper steps to effect sound foundation construction by an adequate and suitable control of drainage has been compelled to cut out one proposed feature after another because of the apparently unwarranted initial expense, because of lack of funds, or of the opposition of local administrative officials who are willing to risk large public expenditures rather than curtail the length of construction. Too frequently the policy has been one of millions for surface and not one cent for drainage.

There has been very little added during this time to our knowledge of the natural conditions that have to be combatted for the purpose of road construction in controlling ground water, capillarity, or frost. It appears, however, that we are at the beginning of a new phase of this matter. Like the competition between the big gun and armor plate designers, that between the manufacturer and operator of motor vehicles and the highway engineer has reached a stage where the engineer must save himself either by agreement or by adopting a new method of defense. The method of agreement lies obviously through legislation which will restrict the wheel loads, control the width and type of tires, and diameters of wheels, and in some measure also control the width of bodies.

BECOMING MATTER OF FOUNDATIONS.

When the recent failure in several States of a considerable mileage of first-class road is considered, it appears that the problem of the immediate future is going to be the development of adequate foundations to handle a fast-growing motor-truck traffic. The last available figures indicate that there are some 200,000 motor trucks and commercial vehicles now registered in the United States. The great majority of these are in the northeastern block of States, with heavy concentration in other States having improved roads.

Whether the increase in number of trucks in the next decade will in any way approximate the increase in pleasure automobiles during the last one is not a matter of special moment, but it is of the greatest importance whether the gross tonnage of trucks increases rapidly. A single truck of some designs will provide a tonnage equal to five or six touring cars. A single truck operating between fixed termini has damaged a road in a single month to more than the ordinary cost of maintenance for a whole year. A string of trucks operating over a road not properly supported by the existing foundation has entirely destroyed in two weeks a well-built surface costing $8,000 per mile.

Such destruction as this must be stopped or the cost of motor-truck hauling, if properly allocated, will amount to prohibitive figures even for 1 or 2 mile hauls. and for long hauls will produce conditions perilously near bankruptcy in many of our counties. An engineer of the Bureau of Public Roads was recently asked what type of road would be adequate to accommodate traffic of 20 tons on two 10-inch steel tires, moving at 20 miles per hour. The inquiry was made because the design of such a trailer was being seriously considered. Just how far the tendency indicated by the above conditions is going to continue cannot be definitely foreseen, but so far as present motor-truck traffic is concerned our existing roads are frequently not adequate.

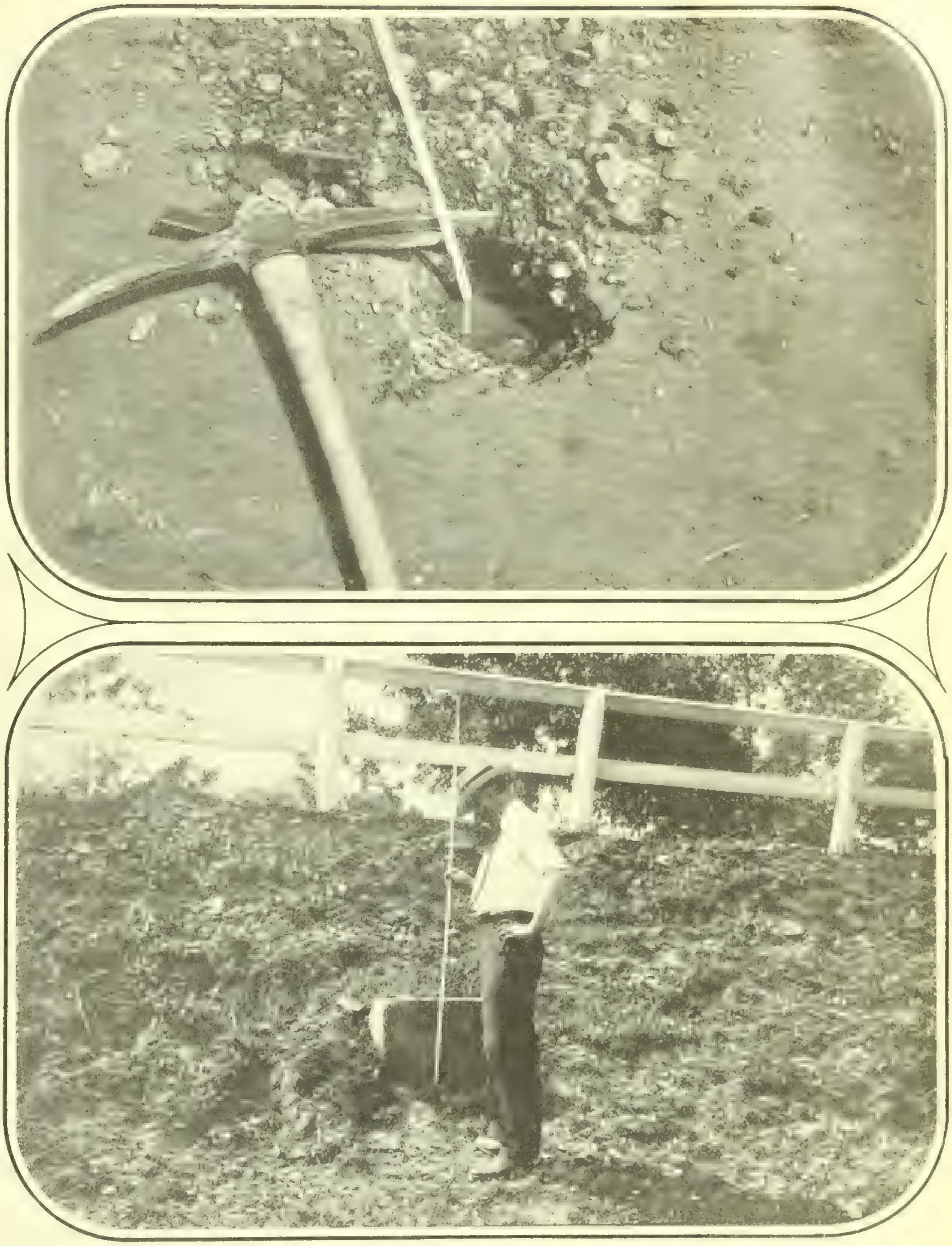
PROLIFIC CAUSE OF FAILURES.

Careful inspection indicates that failures have largely been the result of weak foundations at the time frost is "coming out of the ground," when the water content of the soil is high and foundations are consequently weakened. What degree of weakening is permissible under any conditions before failure is reasonably certain is not known because we never know even approximately the factor of safety in the bearing power of our sub-base or subgrade. The few studies made in this direction have little application to road conditions, because the moisture content of the soil and its grading or texture, which so strongly affect capillarity, have never been adequately considered. Further, it is doubtful if within the immediate future any increase of knowledge of soil conditions will be sufficient to indicate a method of direct control. Capillarity can not be adequately controlled. It must be met.

The same degree of approximation in our road foundation design will doubtless prevail until considerably more data are available regarding soil moisture and its effects. In the meantime such information as we have can be used for what it is worth. Some recent examinations made by an engineer of the Bureau of Public Roads furnish the following interesting data:

Clay below a concrete pavement contained 18.88 per cent by weight, or about 46 per cent by volume, of water. In another case clay contained 12.7 per cent by weight; in still another case, 12.23 per cent. Clay loam under an asphalt pavement on a 7-inch concrete base contained 13.58 per cent by weight, or about 33 per cent by volume, of water.

Sand cushions under grouted brick and on a concrete base have been found to contain 6.38 per cent of water by weight; and under a tar-filled brick pavement and on a concrete base 9.05 to 13.76 per cent. Under wood block on a concrete base the sand cushion may contain as high as 12.7 per cent of water by weight.



TOP - WATER AT BOTTOM OF 8-INCH SURFACE TREATED MACADAM ON A 6 FOOT FILL. BOTTOM - OUTLET OF SUB DRAINAGE SYSTEM FOR THIS FILL OPPOSITE HOLE SHOWN ABOVE TILE STOPPED UP AND OUTLET DRY.

STUDIES OF CAPILLARY ACTION.

These figures may be considered as being the natural moisture content of the various materials under the conditions existing. In every case the structures were first class and believed to be adequately drained.

Some extended studies of the action of capillarity conducted by the Irrigation Division of the Bureau have furnished additional interesting data.

The following table shows the height to which capillary water rises in certain soils in twenty-four hours:

	Inches.
Light sandy soil	14
Gravelly soil	16
Decomposed granite (loam)	21
Heavy granite loam	16
Heavy clay loam	11
Heavy lava ash	16
Pure sand	9

In one day the capillary water moves upward about one-half its apparent final limit. In three days it moves about two-thirds its apparent final limit. In some soils the movement upward in the first two hours is as high as one-third of its movement for 30 days. In pure sand it rises in one-half hour approximately one-half as high as in one day, and in one day about 70 per cent as high as in twelve days.

The movement is more rapid at the start in light soils, and slows down rapidly. After three days the movement is exceedingly slow in pure sand. In heavy soils the movement is uniformly slower and more sustained.

In light soils the per cent of water in the soil decreases rapidly with the height above the source of water, while in some heavy soils the water content is strikingly uniform at different depths.

Horizontal capillarity occurs with much faster water movement and greater uniformity of moisture content. The speed and distance varies with different soils and ranges from 7 to 33 feet in the first 24 hours.

SOURCE MUST BE REMOVED.

An examination of the above figures indicates that capillarity in some cases fills the soil perilously near to the saturation point even when drainage is considered adequate. And the rapidity with which capillary action occurs when there is a source of free water makes it imperative that such source be removed with the greatest promptness and prevented from occurring within a considerable distance, either vertically or horizontally, from soils which are depended upon to support heavy loads.

The action of capillarity indicates that if water is to stand or flow along a road embankment for even a few hours, regard must be given to the height of the subgrade above the water line, and the lateral distance of the watercourse from the road surface.

Assuming that the supply of free water will not endure more than one day at a time, it is apparent that a height of 18 inches in the subgrade above the water line will insure that the moisture content near the surface is not increased. Where the free water is present at a considerable distance to one side this height may safely be reduced. Shallow ditches a short distance from the center line tend, by horizontal capillarity, to increase the water content of the subgrade at a higher level than deep ditches similarly located. If the grade is through standing water or against a continuous source of free water so that the soil remains continuously moist, capillarity will lift the water about 4.5 times higher than in dry soil, and this fact must be considered in designing cross section and grade across swamps, marshes, or against irrigation or drainage ditches in which water is present for long periods.

WHERE SPECIAL DRAINAGE IS NEEDED.

These conditions affect the design of cross section and the establishing of grade in places where the presence of free water is foreseen or where run-off is expected to be slow and considerable, if the full bearing power of the natural soil is to be developed. If the design of cross section can not, because of immediate local conditions, be made to meet the above requirements, then special drainage should be provided or additional bearing value given by some suitable treatment.

The writer recalls a specific case in Florida where a light sand and sandy loam were reinforced by a 4-inch layer of natural sand-clay preparatory to placing wearing surface. The cementing value of the sand-clay mixture was counted upon in the design to furnish a nonflowing base adequate to distribute the comparatively light loads probably to come upon the surface. Wherever the road was located on a ridge or high well-drained natural soil, this base appeared adequate; but where a grade was thrown up across marsh land, swamps, or near standing water in the "flat woods," the elevation above prevailing water level was so little that even when the clay base appeared dry and satisfactory, just so soon as surfacing was laid and evaporation at the surface of the clay thereby reduced, the clay became sufficiently moistened from the underside, by water supplied by capillarity, for the bond of the clay to yield and the base to become more or less plastic and flowing.

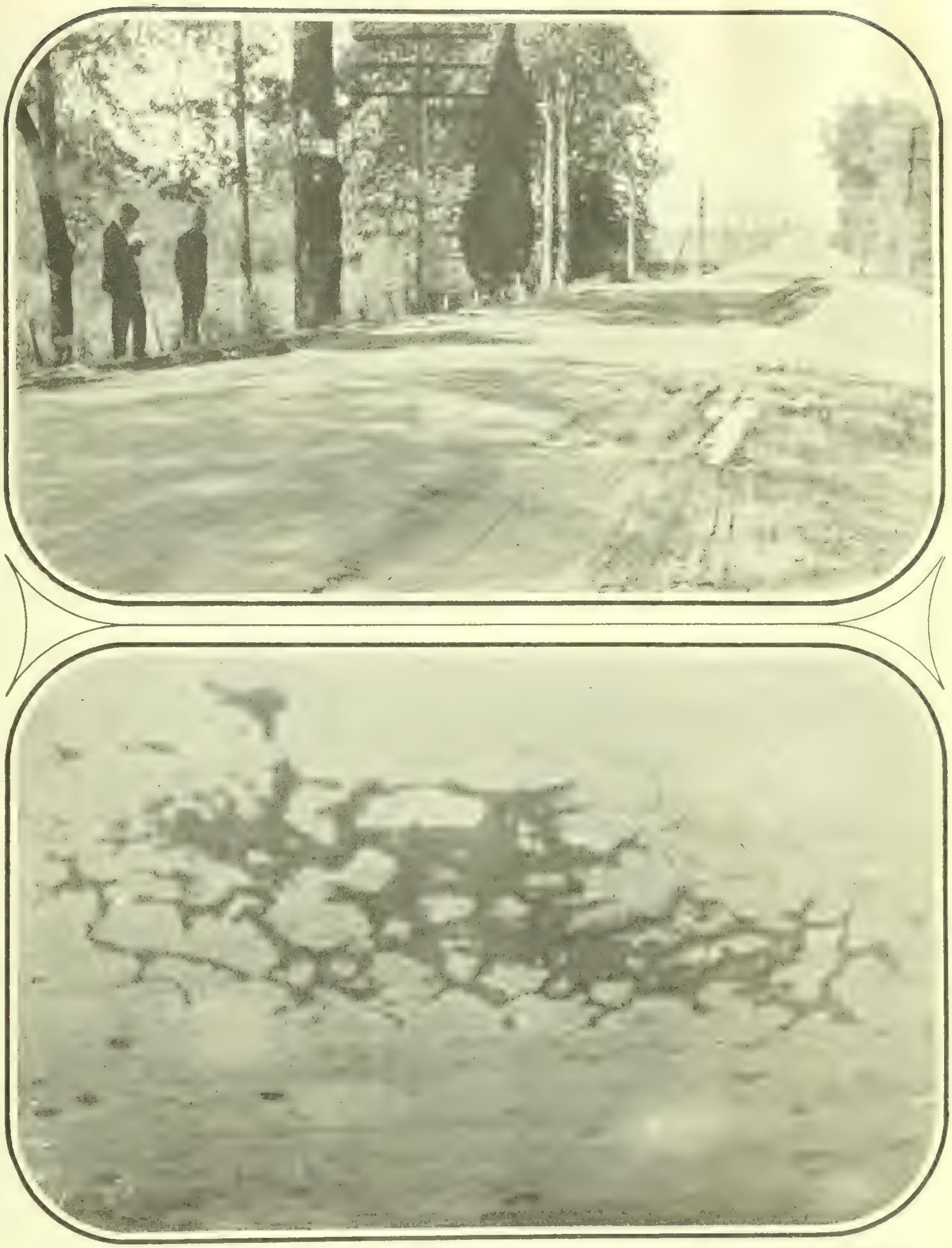
Experience alone has developed many of the features of our present highway cross-section designs. Certain bearing powers of the soil are more or less unconsciously assumed as we follow accustomed practice. Now that the loads likely to come upon our roads are so much greater, it is a problem of the utmost importance to determine how much heavier our foundations must be, just what loads soils with different moisture contents may be depended upon to bear, and what means if any, can be developed to insure no increase of moisture above a safe point. Of course, these problems are closely correlated. How does moisture content affect the bearing power of soils? And ultimately what method of design will be most economical? Will it be cheaper in a given condition to drain excessively or to thicken the foundation? These matters are to-day a closed book to the highway engineer.

Finally, we must face the natural law at work through capillarity and realize that it can not be removed. It must be met.

LITTLE TO ENCOURAGE CHEAP ROADS.

In matters of practice we shall find little to encourage the builder of cheap roads. Tile drains, French drains, the various types of subbase will doubtless have to be used much more extensively in some sections than they have ever been. Grades will have to be kept higher in flat locations and to retain the general crescent design of the crown and thus avoid deep cut ditches, construction lines will be much wider than customary. This will have its effect on width of right of way.

In a few, a very few, States where systematic road construction and maintenance have required the development of an adequate permanent organization of engineers, road builders, and maintenance forces, experience has resulted in producing a practice that more and more completely meets the conditions that the past have caused failure of our roads under increasing traffic or imperfect drainage features. This practice is to consider the design of short sections of road as a local problem. Frequently the cross-section design is changed several times in a mile, gravel base, sand, crushed rock, telford, V-drain, or stone base is placed where needed to meet the local drainage and soil conditions. To be sure, much of this work has been done as betterment or maintenance, subsequent to the original construction. Each spring certain bad locations have been torn up and repaired by providing the necessary drainage or foundation. As engineers will in general realize, some of these failures are due to conditions that were not apparent at any time during the preliminary survey and investigation, and appear to have developed after construction. But the greater part of such repairs are to meet conditions that could have been ascertained by proper preliminary investigation and adequate engineering design preceding original construction.

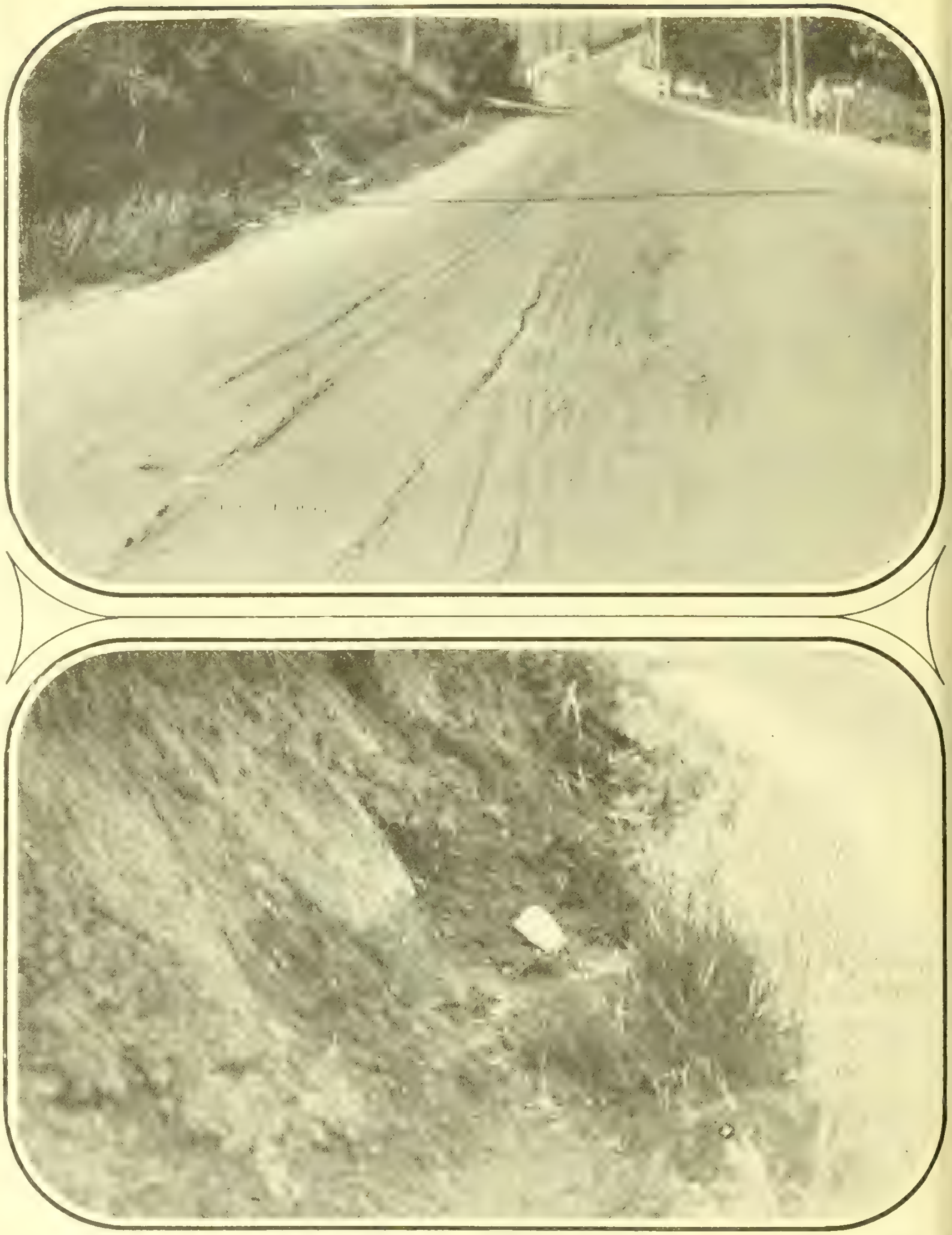


TOP - WATER STANDING IN MUD HOLE ON SHOULDER AT EDGE OF PAVEMENT ON 5-FOOT FILL. BOTTOM - MOISTURE BEING SHOVED THROUGH FROM BASE OPPOSITE MUD HOLE SHOWN AT TOP.

In a great majority of highway plans, however, will be found a single cross-section design, expected to be adequate to meet conditions mile after mile, through cut and fill, uphill and down.

DETAILS WILL BECOME FEATURES.

Under the increasing truck traffic, drainage will have to be considered more carefully, moisture content of many soils in many locations considered allowable under past conditions will have to be reduced to save or develop such bearing value as the soil may have, and a great deal of subgrade will have to be reinforced by the addition of suitable subbase. All of these details, considered heretofore as special features, will become the features ordinarily considered in careful design of high-class, costly pavements. A foundation and wearing



TOP-FAILURE IN 6-INCH CONCRETE ROAD DUE TO SOFTENING OF SUBGRADE BY WATER BEING ABSORBED FROM DITCH WHICH HAS BEEN FILLED UP AND NOT CLEANED OUT.
BOTTOM-WATER STANDING IN DITCH OPPOSITE FAILURE SHOWN ABOVE.

course costing $16,000 per mile are not going to be subjected to what is now known to be an utterly destructive traffic without that due examination of soil conditions and adequate provision for furnishing a proper support in the natural ground that will save the surface and foundation from destruction at a reasonable cost.

Within a few months there has appeared an article in one of the engineering journals in which the writer said that the day of open stone bases was past; that telford, field stone, V-drain, etc., were no more dependable than a firm, well-compacted earth subgrade. This statement in the light of the traffic which has developed in the last six months becomes daily more and more surprising. An earth subgrade can be kept dry only when capillarity is destroyed or its range in distance exceeded, and for most cases the latter possibility is not within the reach of road designs. The writer is more and more convinced that the older types of large stone foundation, with large interstices, included the principles which will be found of greatest effect in resisting the failure of subgrade bearing because of excessive soil moisture. This opinion is strengthened by a consideration of frost action, especially in the spring, when alternate freezing and thawing may be expected.

SALVAGING CAUSES TROUBLE.

It has been the custom in recent years in the limestone sections of Tennessee and Kentucky, when it became necessary to rebuild some of the old "pikes," to salvage the telford, crush it, and place it back as macadam. In one case, at least, this was done on first-class engineering advice, and in this case the result was not satisfactory. The reason for failure appears to have been due to insufficient drainage of the base, which had been provided for years by the old telford and was most carefully closed by the new construction. The result of this condition is greatly emphasized by severe frosts.

Some designs for V-drain, in order to save stone, require that the drain be carried out practically to 0 depth at the extreme edges, so that the stone or other road metal is practically without drainage at those points.

In northern localities difficulty has been experienced when V-drains of this design have been used with the edges of the road crust heaving in the spring. This is probably due to the freezing of accumulated water near the edges of the drain. Such water will accumulate in the interstices as a result of shallow thaws, which do not free the deeper areas of frost. The melted snow can not run off and fills the upper layers of the V-drain, especially near the edges, until the voids are too full to allow expansion on freezing. The result is that during succeeding freezes the edges of such drains will heave. The remedy is to increase the depth of V-drain at the edge and to provide drainage close to the surface through the shoulder, so that such drains will certainly clear with the shallow thaws and permit water to flow freely from the V-drain. Experience indicates that the depth of V-drain, in addition to the surfacing material, should not be less than 4 inches at the edges and that a depth of 6 or 8 inches is better.

OUTLETS SHOULD BE PROVIDED.

Outlets for conducting water away from the V-drain should be provided at all low points in the grade. These outlets may consist of tile running from the lowest point of the V to a culvert or cross-drain, or of ditches filled with the same kind of material as that composing the V-drain and running from the lowest point in the V to any lower point outside of the road where they may empty.

The error has often been made of depending on tile or French drain to remove the excessive and damaging moisture from soils that do not readily give up their contained water. While tile drains for agricultural purposes may in the same soils be entirely satisfactory, because rapidity of action is not essential, they are not adequate for road drainage. The recent failures in Maryland, shown in the accompanying illustrations, disclose that much of the spotty failure on some of the roads is due to pockets of heavy pipe clays left in the subgrade of roads that were, in general, very well drained. The only treatment for such cases is to remove the offending material and replace it for a sufficient depth with sand, gravel, or some sort of stone base having free lateral drainage.

When road construction is approached in the spirit necessary to meet the conditions cited here, the result will be a series of cross-section designs, instead of a single design to meet all conditions, much more general use of subbase and tile drainage, more careful consideration of the material of the subgrade, and the methods used in finishing it. To do these things intelligently, there will have to be undertaken by some one extensive studies of existing conditions. These are matters about which much may be learned by a close and studied observation of failure.

CONSTRUCTING A CONCRETE ROAD AT MARINE CAMP IN THE WINTER

By C. L. BROWN, Senior Highway Engineer, Bureau of Public Roads

THE following description of the concrete-road work done on the highway between Quantico, Va., and the main highway between Richmond and Washington, together with the photographs accompanying it, is given not because the construction of concrete roads is new, or that it possesses any unusual features outside of the time of the year in which it was constructed, but because it is unusual to attempt the construction of concrete roads with the temperature below freezing.

Early in October, 1917, it was decided necessary to build a substantial roadway from the Marine Corps camp at Quantico to the main highway leading to Washington. This road, in the spring of the year and during the wet season, was almost impassable. The drainage is bad. It was very essential that this stretch of road should be improved at the earliest possible date, in order to furnish an outlet by road from the camp to Washington and also provide a means of communication between the artillery range and the camp. The Bureau of Public Roads was called upon to advise with the Navy Department, and after consideration it was decided to construct this road of concrete. It was planned to do as much of this work as possible before the winter season set in, which ordinarily in this latitude is not early.

WORK DONE IN FIVE MONTHS.

The construction company, which had the contract for the construction of the marine camp at Quantico, undertook this work under the direction of Maj. H. L. Roosevelt, post quartermaster of the camp. The writer was detailed by the Bureau of Public Roads to advise the quartermaster and look after the engineering incidental to the construction of this highway.

The work was started late in October and was completed March 13, 1918. During this time the thermometer sometimes reached zero and below, and during a large portion of the time the temperature was between zero and 32° F. It was necessary to adopt all possible measures to protect the concrete, both during its laying and curing.

The engineering features in connection with this were not unusual. The width was 18 feet, the thickness at the center 8¼ inches, and at the sides 6

THAWING OUT THE SUBGRADE

PLANT FOR HEATING THE WATER

HEATING THE GRAVEL

HEATING MATERIALS

inches. The road is reinforced with a wire mesh reinforcement weighing 28 pounds per 100 square feet. The concrete was mixed in the proportions of 1 part Portland cement, 1½ parts of fine aggregate, and 3 parts of coarse aggregate that consisted of washed and screened gravel. The grade and alignment followed the old roadway as nearly as possible and the few short, steep grades were reduced and some of the excavated material wasted to avoid heavy fills, which would undoubtedly settle later and cause bad cracks in the roadway.

PLANK ROAD FOR TRAFFIC.

Investigation proved that a good detour could be provided to the east of this road, which would allow the road to be entirely closed to public travel without serious inconvenience. The traffic incidental to the construction of the road was taken care of during the construction of the concrete road by the construction of a plank road along the side of the highway.

A camp was constructed for housing the laborers at a point midway between the two ends of the road. At this point were also constructed the stables for the live stock. Cement sheds were built at convenient places and filled with cement before the pavement reached these points. The storage of the cement was not sufficient and the necessary balance was hauled by truck and teams from Quantico during construction.

The usual method of construction of this kind of work was pursued until it became necessary to keep the concrete from freezing. The work was begun on the end of the road farthest from Quantico and continued toward Quantico. Later, work was started at Quantico and carried on simultaneously with the other work. For the first two weeks after starting the work was carried on night and day. It was then decided to abandon the night shift and work only the day shift.

About November 23, 1917, it became necessary to adopt precautions against freezing. There was a great deal of delay due to the difficulty in obtaining from a commercial plant in Fredericksburg sand and gravel which they were unable to wash during the extreme cold weather.

HOW CONCRETE WAS PROTECTED.

The road was graded and the necessary drainage structures built as far in advance as possible of the concrete work. The sand and gravel were delivered during construction when they could be obtained, and were hauled in and dumped in rows on the subgrade ahead of the mixture. Care was taken to deliver the materials in the right quantities for the concrete and avoid the hauling in of materials after the work was started.

When it was decided that the work must proceed regardless of the weather, attention was given to the question of protecting the concrete, and the following methods were adopted: These methods constituted practically the unusual features in the construction of this road and are well illustrated by the photographs accompanying this article. The water was pumped into an elevated tank and from there flowed by gravity into a tubular boiler, where it was heated. In dumping the sand and gravel in rows on the subgrade, plain sheet iron pipe about 2 feet in diameter was first laid on the subgrade and the material dumped on this. Fires were built in these pipes and in this way both the sand and gravel were heated to a proper temperature. These fires also served to keep the subgrade from freezing so that the concrete could be laid on an unfrozen subgrade. After the materials had been properly heated, mixed, and deposited, the finishers followed up the work immediately.

A mixer of two-bag capacity was used to mix the concrete. This mixer had a 20-inch revolving iron tube 18 feet long on the discharge end. This tube allowed a much drier mixture to be used and deposited the concrete in the best possible condition on the roadbed. The mixture was held in the mixer for one minute. The strike board was of a heavy plank cut to the crown of the road and the wearing edge shod with sheet iron.

ROLLER GIVES GOOD RESULTS.

At first a small wooden hand float was used to finish the concrete surface, but later a Macon roller was used with very good results. The roller was 6 feet long and 10 inches in diameter. It was passed over the surface of the road from one edge to the other and back again; then advanced one-half its length and the rolling repeated. This operation was kept up until the roller reached the unscreeded concrete. After a short wait the rolling was repeated.

After the cold weather set in and it became necessary to protect the concrete the previous method was used as far as possible, but at times it was necessary to omit the second rolling and cover the concrete at once. The method of covering the concrete is shown in one of the illustrations. Four-inch by 4-inch blocks 1 foot long were placed on the side forms on each side of the road, and 2-inch by 12-inch planks, 20 feet long, were stood on edge on these blocks and spiked to them. These planks spanned the pavement at as frequent intervals as necessary. On these planks were placed 2-inch by 6-inch planks lengthwise of the road. Over these in turn was spread a heavy canvas that covered the top and came over the edges and rested on the ground. Marsh hay was then spread over the canvas and banked against the sides, thus shutting out the cold air. The concrete then was covered until danger of damage by frost had passed, then the covering was moved ahead and used over again. Several thousand feet of this pavement were in service during the winter. It was covered with snow and ice and many auto trucks and light vehicles passed over it, but in the spring the surface showed no signs of frost action.

PLACING MATERIAL

PROTECTING THE CONCRETE

JOINTS SPACED IRREGULARLY.

No attempt was made at the regular spacing of the joints; they were placed from 50 to 150 feet apart. The joint filler was three-eighths inch thick, made up of an asphaltic strip which extended entirely across the road. As used at first, the filler extended above the surface of the concrete a half inch, but later the concealed joint was used. This latter method allowed the surface to be finished continuously, making a smooth joint. Where the filler extended above the surface it was hard to get both sides on the same plane.

Until the ground became frozen it was a simple matter to do the excavating and grading. After the frost was in the ground it was found by experiment that a heavy wood fire built on the ground would remove the frost to a depth of 10 to 14 inches. As there was plenty of wood to be had for the cutting this method was adopted. Logs were cut 10 feet to 15 feet long and a heavy fire was built over the full width of the subgrade. After the frost was out of the ground the fire was worked ahead and the excavation carried down to the finished subgrade. The good supply of wood so close at hand was one great advantage of this method of softening up the ground.

There was one cut where the excavation was too deep to be taken out this way, so holes were drilled below the frost line and the ground loosened up with dynamite.

The steam jet method was tried but did not give satisfactory results.

The results show that it is possible to build a concrete pavement during freezing weather, but, if possible, it is better to postpone the work until warmer weather.

WASHINGTON MAKES A RECORD IN FEDERAL AID ACCOMPLISHMENT

THE State of Washington has attained distinction in the record of Federal aid progress. It is the only State with more than one project that had all of its projects under final agreement before May 1, 1918, provided for the expenditure of its complete apportionment, $215,642.72, for the first two years, had six of its seven projects under contract before the first of this year, and completed its first project January 21, 1918. The five other projects averaged one-third complete on the first of May. No further agreements involving work to be done prior to July 1 could be made before that date.

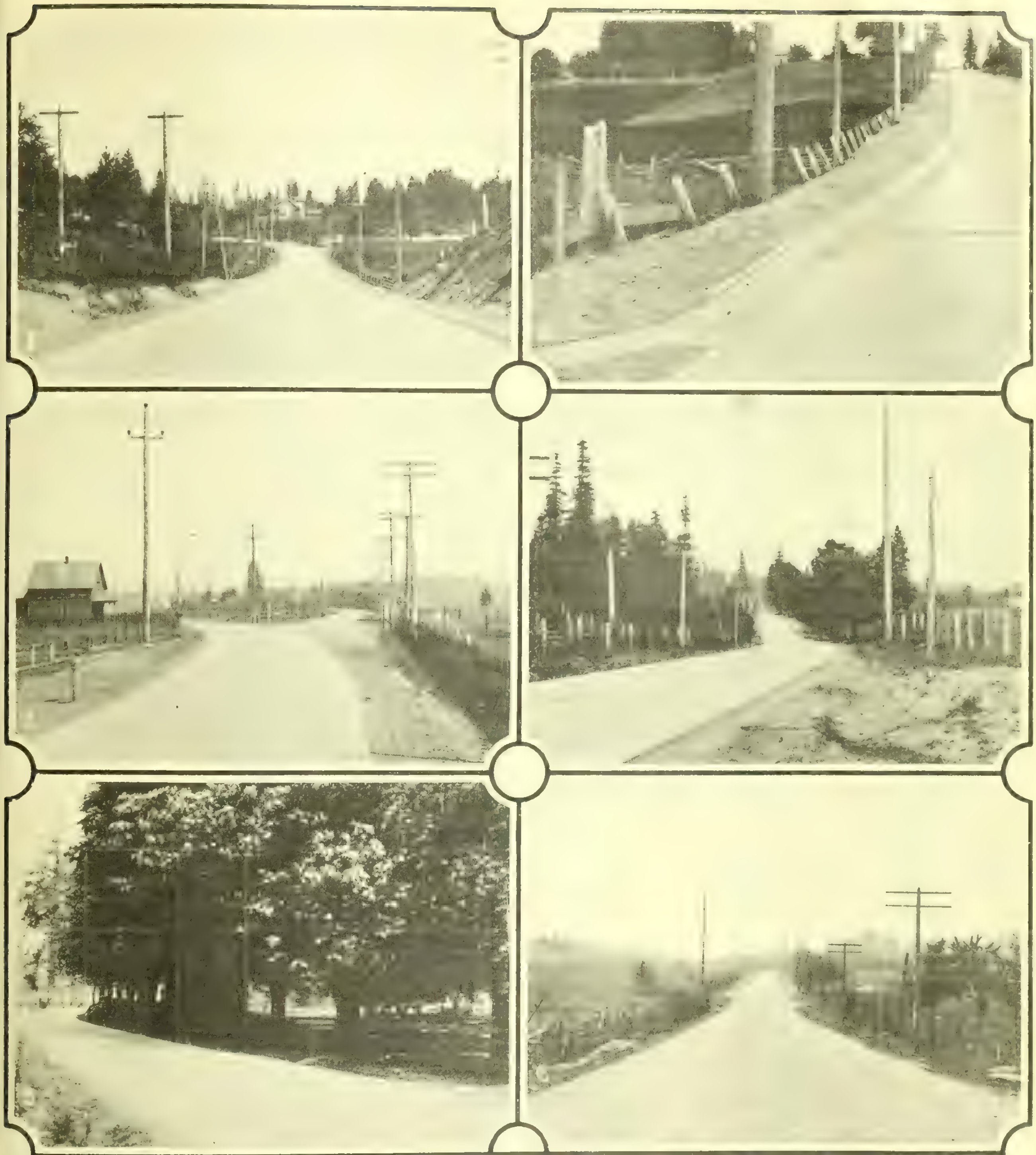
Washington's first completed project is 3.52 miles of concrete pavement on the Pacific Highway, leading northeasterly from Olympia to Camp Lewis, Tacoma, and Seattle. It is on the main highway route from California and Oregon, crossing the Columbia River at the interstate bridge between Portland and Vancouver, reaching the southernmost inlet of Puget Sound at Olympia, and generally paralleling the easterly shore of Puget Sound to the international boundary and the British Columbia cities beyond the border.

Prior to the Federal aid, about 15 out of the 25 miles between the city limits of Olympia and Tacoma had been permanently improved with hard-surface pavements, 1 mile easterly from the Olympia limits and 14 miles southwesterly from the Tacoma limits; the intervening 10-mile section being a well-improved gravel-surfaced highway. Under the heavy traffic, reaching 600 vehicles per day, and increasing constantly, this 10-mile gravel-surfaced section required an annual expenditure averaging $500 per mile for repair and upkeep. Moreover, under such traffic, adequate maintenance to proper standards of smoothness had become impossible at any expenditure.

WORKED THROUGHOUT SEASON.

Under these conditions the extension for 3½ miles northeasterly from the 1-mile section of concrete pavement constructed in 1916 easterly from the Olympia city limits was made the subject of the first Washington project with Federal aid. Application was made March 24, 1917 (within two weeks from the passage of the State act assenting to Federal aid); project approval followed April 26, and plans, specifications, etc., received final Federal approval July 19, 1917, the contract, however, having been let June 9, 1917. The work continued throughout the season of 1917, sections of the pavement being thrown open to the heavy traffic as soon as it was deemed sufficiently seasoned, the whole 3½ miles being in use by December 8, 1917. Final completion was certified January 21, 1918. The total cost was $64,580.32, of which $30,865.22 was provided by Federal aid and $33,715.10 from State and Thurston County permanent highway funds.

The type of construction is one-course concrete, 1-2-3 mix; the pavement is 20 feet in width, flat base, 6 inches thick at edges, 7½ inches at crown. The maximum curve is 8 degrees, with extra width and superelevation, making double-track traffic entirely safe at 35 miles per hour. The old gravel highway had a roadbed of ample width and furnished an ideal base with only minor revisions of location to ease a few curves. Comparatively slight subgrading was necessary and the material thus obtained supplied ample



WASHINGTON'S COMPLETED FEDERAL AID PROJECT.

① FIRST QUARTER MILE ② 400 FEET EAST SHOWING DETAIL OF EXTRA WIDTH GUTTER CURB, AND OUTLET TO PROTECT SHOULDERS AND SLOPES FROM DRAINAGE RUTS AND WASHOUTS. ③ HOW DANGEROUS GRADE CROSSING WAS AVOIDED ④ LEADING TO "CLOSE UP" CURVE. ⑤ "CLOSE UP" CURVE ROUNDING AN OLD PIONEER HOMESTEAD. ⑥ 500 FEET BEYOND 5 LOOKING BACK OVER OLD GRAVEL ROAD AND SHOWING CONTRAST.

shoulders, nowhere less than 5 feet wide. Altogether the project includes a broad-guage pavement on an ample roadbed. The grade maximum is 5 per cent, the general project being level, with undulations varying not to exceed 50 feet in their extremes.

NOT A DEFECT IN SIX MONTHS.

With a winter season's exposure to more than usual possibilities of washouts and settlements, and under an increasingly large volume and heavier tonnage of constant traffic, not a single defect manifested in the first six months of use. Not a dollar of maintenance cost has been required throughout that period, in marked contrast to the $500 per mile annual average for inadequate maintenance of the former graveled highway. With this object lesson, Thurston County has recently voted a bond issue sufficient (with some Federal aid from the third fiscal year apportionment) to extend similar concrete pavement over the 6½ miles of remaining gravel section to connect with the pavement 14 miles south of Tacoma.

Washington Federal aid project No. 1 was carried to completion under the constant personal oversight of State Highway Commissioner James Allen, whose headquarters at Olympia made frequent inspection convenient throughout the construction period. District Engineer Eugene R. Hoffman was in direct supervision of the work from its design and specifications through to final completion. Included in the first draft call three months after this important public work had commenced, Commissioner Allen secured Engineer Hoffman's exemption without his knowledge or consent, on the proper ground of the responsible work he had in hand. While this exemption was granted without limit, Mr. Hoffman declined to await another draft call, and joined an engineer regiment as a volunteer in January, as soon as Federal aid project No. 1 and an important companion project (concrete overcrossing of Northern Pacific Railway on the Pacific highway at Nisqually) were completed. He was almost immediately assigned to duty in France, after only a month of training at Camp Dix.

FEDERAL AID RECORD IN MAY.

In May the Secretary of Agriculture acted upon 111 projects, 35 of which went to final agreement. All covered 939.32 miles of road, for which the States estimated that they would expend $6,947,805.56, and asked Federal aid to the extent of $2,424,217.19.

Texas led in the number of projects acted upon, 15 of them reaching approval. The mileage involved is 249.7, the estimated cost $1,234,267.19, and the Federal aid allowed $440,829.37. Arkansas came next with 11 projects, covering 53.12 miles of construction, at an estimated cost of $312,398.20, toward which $112,992.23 was allowed as Federal aid. In 10 projects approved for Wisconsin that State undertook to build 48.7 miles of road for $337,355.01, with $111,863.66 of Federal aid.

While there were only five Pennsylvania projects approved, they were all of concrete construction, involving 49.08 miles to be built at an estimated cost of $1,535,587.37, toward which the Federal Government will allow $490,870.

Georgia is spending its money and $83,108.08 for the building of six bridges, for which it intends to pay $235,003.40. Oklahoma also has one bridge project which figures to cost $175,000, including the allowance of $50,000 Federal aid.

The most expensive single project is one in Pennsylvania, 32.82 miles of concrete in Dauphin, Lebanon, and Berks Counties, to cost $938,080 with a Federal aid allowance of $328,200. The longest single project is 59.20 in Bosque County, Tex., and the shortest 0.66 mile of brick or concrete in Lewis County, W. Va.

MAY FEDERAL AID STATISTICS.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved	Project agreement executed	Estimated cost.	Federal aid allowed.
Alabama	28	Coosa	5.89	Topsoil		May 29	$30,463.87	$15,231.93
Arizona	1	Pinal		Bridge		May 20	[1] 8,023.84	[1] 4,000.00
Arkansas	8	Lonoke	1.97	Water-bound macadam		May 29	8,871.72	3,169.00
	9	Monroe	8.08	Gravel, asph'lt carpet coat	May 10		74,943.66	37,471.83
	10	Cross	1.46	Gravel		May 29	4,532.15	2,266.07
	11	Woodruff	2.99	Bituminous macadam		...do...	22,459.69	10,000.00
	12	St. Francis	7.60	Gravel		...do...	22,368.50	10,000.00
	13	...do...	1.91	...do...		...do...	26,180.00	5,467.10
	14	Jefferson	5.15	...do...		...do...	21,100.50	10,000.00
	15	Prairie	1.50	Bituminous gravel		...do...	25,197.83	10,000.00
	16	Lawrence	4.57	Macadam	May 10	...do...	22,698.22	7,500.00
	17	Craighead	5.81	...do...	...do...		69,539.55	10,000.00
	18	Benton	6.05	Gravel	May 6		14,236.47	7,118.23
Delaware	2	Sussex	11.60	Concrete	May 17		125,590.00	2,000.00
Georgia	2	Chattooga	13.40	Gravel	May 21		33,000.00	15,000.00
	7	Macon	0.89	Two bridges	May 2		119,964.83	59,982.41
	11	Lowndes	0.42	...do...	May 23		55,088.57	25,000.00
	13	Muscogee	0.34	...do...	...do...		59,950.00	29,975.00
Iowa	13	Webster	12.00	Gravel	May 21		56,466.17	28,233.08
	15	Mills	13.00	Earth	May 9		45,870.00	17,455.35
Kansas	5	Bourbon	8.70	Water-bound macadam	May 28		60,812.44	9,121.87
	12	Geary	1.12	Concrete or brick	May 24		38,311.41	11,200.00
Kentucky	4	Carter	11.53	Earth	May 18		95,810.00	47,905.00
Michigan	6	Osceola	11.105	Gravel		May 29	148,496.85	74,248.83
	18	Grand Traverse	3.112	Gravel or macadam	May 4		44,050.05	22,025.02
	20	Van Buren and Kalamazoo	5.585	Concrete		May 25	131,152.08	55,850.00
Minnesota	3	Mille Lac	30.58	Gravel		May 8	127,312.17	50,000.00
	6	Carver	26.49	Earth		May 29	54,932.37	15,000.00
	10	Renville	12.00	Gravel	May 6		40,000.00	15,840.00
	12	Washington	5.265	...do...		May 25	20,089.61	10,000.00
	17	Carlton	12.00	...do...	May 13		29,700.00	11,500.00
	19	Goodhue	4.60	...do...		May 29	35,508.99	10,000.00
	20	...do...	21.85	...do...	May 6		82,599.00	35,000.00
	21	Wabasha	15.10	Earth	...do...		39,558.75	15,000.00
Mississippi	17	Hinds	4.26	Gravel	...do...		14,756.50	7,378.25
	19	Montgomery	9.11	...do...	May 2		30,573.84	15,000.00
	21	Lowndes	7.24	...do...	May 6		17,897.00	7,500.00
	22	Benton	11.80	...do...	May 2		68,097.18	24,000.00
	25	Amite	7.14	...do...	May 6		27,590.20	13,795.10
	26	...do...	7.86	...do...	...do...		22,643.50	10,000.00
Missouri	3	Vernon	6.51	Macadam		May 2	11,514.00	10,378.54
Montana	5	Big Horn	2.00	Gravel	May 9		9,949.28	4,974.60
	6	Dawson	12.00	Gravel, shale surface	May 14		19,210.00	9,605.00

[1] Amount increased over estimate previously approved.

MAY FEDERAL AID STATISTICS—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed	Estimated cost.	Federal aid allowed.
Montana	7	Dawson	[illegible]	Gravel	May [illegible]		$19,853.24	[illegible]
	8	Meagher	10.50	Earth	May [illegible]		[illegible]	12,045.00
Nevada	7	Washoe	9.50	Gravel [illegible]	May [illegible]		81,954.40	40,977.20
New Hampshire	8	Sullivan	0.74	Telford base, modified a[illegible]		May 23	[illegible]	[illegible]
	9	Coos	0.85	Bituminous [illegible]		May 20	15,369.69	[illegible]
	16	Hillsborough	2.26	Modified asph[illegible]	May [illegible]		40,000.00	[illegible]
New Mexico	7	Quay	2.82	Earth, [illegible]		May 29	12,179.27	6,089.63
North Carolina	5	Burke	......	Topsoil		May 13	......	[illegible]
	14	Halifax	8.01	Clay gravel		May 29	19,017.83	5,000.00
	16	Haywood	14.29	Gravel and [illegible]		May 1	64,705.05	15,000.00
	23	Burke	[illegible]	Topsoil	May [illegible]		35,693.68	7,500.00
North Dakota	8	Eddy	9.29	Gravel		May 28	22,771.38	11,385.69
	22	Towner	21.20	Earth	May 11		15,943.00	7,971.50
	23	Lamoure	10.00	do		May 29	9,641.67	4,820.83
Ohio	18	Highland	[illegible]	Macadam	May [illegible]		140,993.00	27,119.50
Oklahoma	[1] 1	Cleveland and McClain	0.372	Bridge	May [illegible]		175,000.00	50,000.00
Pennsylvania	9	Butler	[illegible]	Reinforced concrete		May 11	111,954.92	36,900.00
	10	Lawrence	2.29	do		May 13	101,331.47	[illegible]
	11	Lycoming	[illegible]	do		May 16	249,298.39	69,570.00
	16	Butler	3.33	do		May 28	134,922.59	[illegible]
	17	Dauphin, Lebanon, and Berks.	[illegible]	Concrete	May [illegible]		938,080.00	328,200.00
South Dakota	2	Lincoln	10.00	Gravel	May [illegible]		41,553.16	[illegible]
	5	Minnehaha	3.00	Concrete or macadam	May [illegible]		50,304.01	19,716.82
	6	Moody	9.13	Earth, partly graveled	May 28		[illegible]	13,387.22
	7	Deuel	8.60	Gravel	May 29		28,943.38	14,471.69
Tennessee	1	Hamilton	[illegible]	Waterbound macadam		May [illegible]	54,737.67	25,937.07
	2	do	3.60	do		May 1	36,909.69	18,454.84
Texas	8	Hays	24.68	Gravel, bituminous top		May [illegible]	46,926.55	21,56[illegible]
	9	Lee	6.35	Gravel, concrete culverts	May 1		21,513.13	[illegible]
	21	Dallas	.972	Concrete		May 13	27,182.84	9,720.00
	32	Harris	3.183	Bituminous concrete		May 23	129,317.36	[illegible]
	48	Bosque	59.20	Gravel	May 20		237,208.81	[illegible]
	50	Coke	18.65	Sand-clay and gravel	May 6		[illegible]	20,000.00
	51	Madison	15.00	Gravel	May 31		57,035.00	25,000.00
	53	Jefferson	5.60	Concrete or shell, bitumonous surface	May 6		94,237.00	20,000.00
	56	do	5.40	Concrete	do		88,968.00	20,000.00
	58	Ellis	11.54	Macadam	May 22		133,102.20	[illegible]
	60	Randall	19.00	Sand-clay	May 21		[illegible]	11,880.00
	62	Foard	30.25	Gravel and sand-clay	May 6		59,221.00	20,000.00
	64	Fannin	8.90	Gravel and concrete	May 22		75,645.90	[illegible]
	65	Fisher	23.00	Gravel	May 6		[illegible]	35,000.00
	70	Colorado	18.00	Bituminous and gravel	May 18		103,554.00	[illegible]
Vermont	1	Chittenden	0.922	Gravel		May 23	18,436.29	9,218.14
Virginia	7	Albemarle	3.163	Macadam	May 28		[illegible]	[illegible]
	8	Lee	.043	Bridge	do		16,370.00	[illegible]
Washington	8	Douglas	18.65	Macadam	May 18		127,500.00	[illegible]
	9	do	6.43	Gravel or macadam	do		[illegible]	18,750.00
	12	Thurston	3.55	Concrete	May 23		87,954.10	35,000.00
West Virginia	13	Roane	1.00	do	May 28		16,150.00	[illegible] 075.00
	15	Jackson	1.00	do	May 10		[illegible]	10,000.00
	21	Lewis	.66	Brick or concrete	May 18		21,335.00	[illegible] 935.00
	22	Hancock	1.051	Brick on concrete base	May 17		[illegible]	8,550.00
	23	Kanawha	3.00	Asphaltic concrete	May 11		73,220.12	20,000.00
	24	Preston	3.85	Bituminous macadam	do		36,960.00	10,000.00
Wisconsin	24	Jackson	2.50	Concrete	May 6		44,998.12	14,999.37
	28	La Crosse	2.32	Bituminous macadam	May 18		42,368.59	[illegible]
	29	Washburn and Burnett	9.90	Earth	May 29		30,810.82	10,270.27
	32	Winnebago	3.52	Concrete	May 18		74,838.48	24,946.16
	34	Iowa	8.17	Earth	May 27		[illegible]	7,623.00
	35	Dodge	3.18	Gravel or macadam	May 1		29,958.50	[illegible]
	36	Milwaukee	.78	Concrete	May 11		22,978.39	[illegible]
	41	Grant	2.16	Earth	May 6		20,713.00	6,904.33
	43	Trempealeau	3.30	do	May 11		17,985.11	5,995.04
	44	Juneau	11.87	Earth, partly sand-clay surface	May 28		29,865.00	9,955.00
Wyoming	3	Lincoln	6.23	Earth	May 20		13,428.14	6,714.07
	13	Carbon	13.88	do	May 11		[illegible]	7,250.37
	15	Lincoln	2.81	do	May 28		[illegible]	7,984.84
	18	Uinta	[illegible]	do	May 29		5,940.00	2,970.00
Total	111		939.3203				6,947,805.56	2,424,217.19

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[1] Increased Federal aid allowance on project previously approved.

SEES BENEFIT IN REGULATING USE OF ASPHALTIC OIL.

What will be the probable effect upon the use of asphaltic oils in road construction of the regulations of the United States Fuel Administrator? The direct answer is that the use of asphaltic oil in road construction will be heavily curtailed. This statement of facts is or should be self-evident to all readers who have followed the effects of the war upon the industries of the country for the past few months, and the fact that fuel-oil regulations were necessary would, to the thinking man, imply automatically that the use of oil for other than fuel purposes must be curtailed.

As to the extent to which the use of asphaltic oils will be limited in road construction and maintenance, it would be as impossible to even approximately estimate as it would be to state with any reasonable accuracy the probable duration of the present war.

Personally, I would plead for the anticipation of Government curtailment, and believe that every person interested in road work is under moral obligation to his country to refuse to bid upon work which is not essential, and if necessary to change occupation to some essential war industry for the period of the war in order to assist, rather than hamper, the efforts of the Fuel Director. In other words, I would state that the question to each person interested in road construction should not be

"How can I get this across and get this material?" but rather "How can I best arrange that the use of this material will not be necessary as long as it is needed by the Government for other purposes?"

Aside from the quantity which may be available, and from the attitude of those who need, or think they need such material under present conditions, there is one very important bearing which a shortage of asphaltic oil will have upon the road question, and in this respect I believe that the above shortage will be a blessing in disguise.

It has long been the custom of county and city officials and road contractors to underestimate the real value of asphaltic road oils, the reason for this being that the material has in the past been comparatively cheap, and there has been a tendency to take a long chance at getting good results upon poorly prepared roadways, with the result that the work has been improperly done and only partially staisfactory results secured.

Under present conditions it will be necessary to secure the maximum of efficiency from each gallon of asphaltic road oil available for road treatment, which will lead to a more careful study of the essentials of successful treatment, and in the end, I believe, will result in vastly improved construction of roadways intended for asphaltic oil treatment.

The writer, after over seven years of practical experience with road oil treatments in the southwest, is willing to stand by his early declaration, that the best road it is possible to construct is none too good to oil, and this follows directly in line with my statement above, that I believe the present curtailment of asphaltic oil for road purposes will ultimately be of vast benefit.

—Ph'lip Bell, Dallas, Tex.

STATE AID ONLY FOR WAR NEEDS.

The executive committee of the New Jersey State Highway Commission has decided to withhold approval of State aid from all highway projects not vitally essential to the war needs and activities or to the economical welfare of the various counties in the State. It was further decided that to be eligible for State aid for highways the counties and municipalities must properly maintain the routes of the New Jersey highway system that lie within their respective borders until such time as the commission will assume jurisdiction.

CELEBRATE OPENING OF HIGHWAY.

The State and citizens celebrated early in July the completion of the Asheville-Charlotte highway, a part of the scenic roads through the North Carolina mountains. Addresses were made by the governor and members of the State Road Commission.

ROADS AT $81,000 A MILE.

An adequate idea of the present cost of road construction may be gathered from three bids received recently by the New Jersey State Highway Department for the construction of one and eight-tenths miles of Route No. 1 of the State highway system from Menlo Park to Metuchen. The lowest of these bids was for $145,000, or a fraction more than $81,000 per mile. These bids were the first received for the proposed work on the State highway system and afford a possible basis for estimating the actual cost of construction as compared with the engineering estimate of the department, which was lower than the lowest bid. The roads will be 10½ inches of concrete in the center and 8 inches on the sides, with macadam shoulders 3 feet wide.

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING ROAD PUBLICATIONS.

NOTE.—(Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free).

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

BULLETINS.

(In applying for these bulletins the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28").

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.

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OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given, as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. (1911.) 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. *239. The Corrosion of Fence Wire. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c.
*461. The Use of Concrete on the Farm. 5c.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given, as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction 15c.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates
Vol. 11, No 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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FARMERS IN FIRST-LINE TRENCHES OF THE FOOD ARMY

The efforts and achievements of the millions of farm men and women have been noble and remarkable. The farmers have occupied the first-line trenches of the food army. They and the agencies assisting them—the Federal Department, the State colleges, and departments of agriculture—were prepared when we entered the war and had been for years, and I venture the assertion that no section of our people and no agencies have done a better job. They were charged with the responsibility for maintaining and increasing food production. How they have discharged their tasks the results of last year's production operations and of this year eloquently testify. But farmers are not spectacular performers—they never are. They do not furnish sensations and headlines. They have no fixed labor day. They work in season and out of season—from early morning till dusk; but they do not work in the limelight. They are not in the view of people living in cities, the centers of intense publicity.

Urban dwellers ordinarily devote very little thought to rural districts and to sources of food supply. Heretofore they have not had to think much about food. If it is abundant, as it usually is, they take it for granted. If it becomes scarce, they develop hysteria and an amazing capacity for making suggestions. Within the last year city people have manifested an intense interest in food, and, not knowing their Government, some of them have developed the highly interesting proposal that some Government agency should be created to give attention to production. They have seen windows placarded and papers filled with pleas for conservation, for investments in Liberty bonds, and for subscriptions to the Red Cross. They have wondered why they have not seen similar evidence of activity in the field of production. They do not know of the thousands of men and women quietly working in every rural community of the Nation and the millions of bulletins and circulars dealing with the problems from hundreds of angles. They forget that the field of work lies outside the city. They do not recognize that both the problem and the method are different.

It is one thing to ask a man to save. It is one thing to ask a man to invest in Liberty bonds. These things tremendously aid the Nation; but they are also a certain benefit to the individual. It is another thing to ask a man to put his labor and capital into the production of food, facing the hazard of the weather, of distribution, and of the market. Advice to him to do so is one thing; assistance to him to lessen his hazard is another; and such assistance is furnished so quietly that a great part of the Nation knows nothing of it and innocently assumes that nothing is done.—*Extract from speech of Secretary Houston at Dubuque, Iowa.*

E. S. WHEELER
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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 4 WASHINGTON, D. C. AUGUST, 1918

SPANNING CANYON DIABLO, SKAGIT RIVER, WASHINGTON NATIONAL FOREST

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both houses of Congress. Others desiring to obtain PUBLIC ROADS can do so by sending 15 cents for each number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

It is the desire of the Bureau of Public Roads and the Government Printing Office to issue PUBLIC ROADS regularly each month, but it must be borne in mind by the readers that in these war times the tremendous volume of emergency printing takes precedence in the Printing Office and due allowance be made for numerous and unavoidable delays.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

BUREAU OF PUBLIC ROADS

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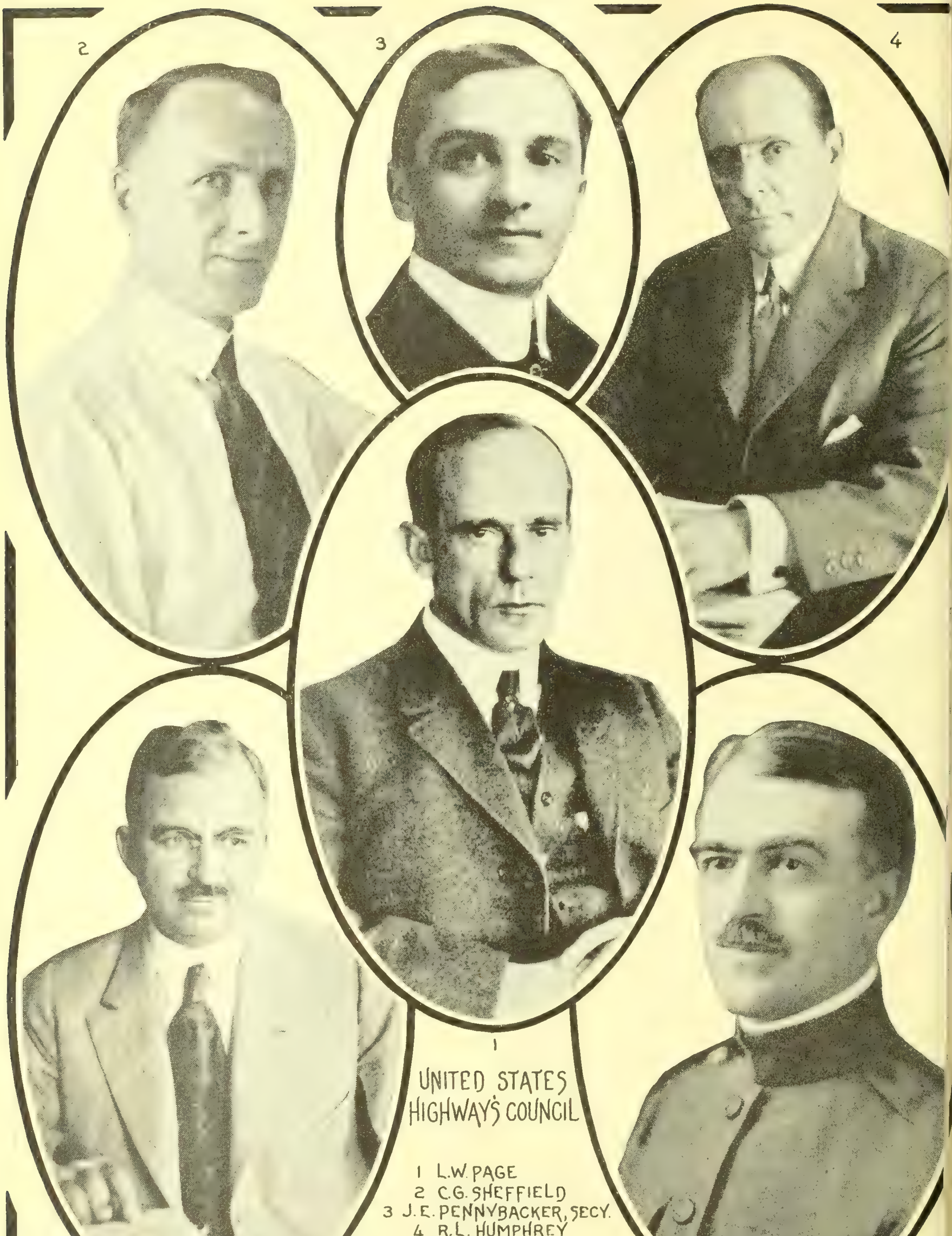

UNITED STATES
HIGHWAYS COUNCIL

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4 R.L. HUMPHREY
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U. S. HIGHWAYS COUNCIL ANNOUNCES POLICIES COVERING ROAD PROJECTS

IN its Bulletin No. 1, just issued, The United States Highways Council announces its policy and procedure as to highway and street work in the country for the period of the war. The regulations therein stated become effective September 10. They make for the conservation of time, money, material, and man power throughout the country so far as highway work is concerned. They make possible the allocation of materials and the expenditure of resources to the greatest possible advantage and with a single purpose in view—to do all possible toward a victorious outcome of the struggle in which we are engaged.

All propositions relating to highway, street, culvert, or bridge construction, reconstruction, and maintenance in which are involved the issuance of bonds, the use of rail or water transportation, the use of coal or oil as fuel, or the use as highway material of cement, asphalt, oil, tar, steel, crushed stone or brick (and of sand and gravel where a shortage exists), must be submitted through the respective State highway departments for approval of the council.

It is realized that new construction, much curtailed in extent, will be found essential, and it will be the policy of the council to deal with this first from the standpoint of its military value and second from that of its national economic value. Reconstruction can receive favorable consideration only where it is evident that maintenance is no longer possible except at prohibitive cost.

In the policy of the council and the construction of a highway program the highway departments of the States can be of inestimable help to the council and the Nation. A careful and selective scrutiny of the projects submitted by the town, county, and municipal officials will eliminate those less essential and enable the council to give material aid in the projects approved.

The text of the bulletin follows:

UNITED STATES HIGHWAYS COUNCIL.

BULLETIN NO. 1.

Effective September 10, 1918.

The United States highways council makes the following announcement with reference to policy and procedure as to highway and street work during the period of the war:

1. All proposed highway, street, culvert, and bridge construction, reconstruction, and maintenance involving: (*a*) The issuance of bonds; (*b*) the use of rail or water transportation; (*c*) the use of coal or oil as fuel; or, (*d*) the use of cement, brick, asphalt, oil, tar, crushed stone, or steel (also sand and gravel where shortage exists) as highway material, should first be submitted for approval to the United States highways council through the appropriate State highway department. Forms have been prepared for this purpose and a supply placed with each State highway department. No manufacturer will furnish any road building material until the project has been approved by the United States highways council.

2. The council again urges that new highway and street construction be confined to the most essential needs. If this is done there will be a far greater probability that the work thus selected can be promptly and effectively carried through to completion than if an amount far in excess of the available facilities were to be undertaken.

The council in passing upon the projects which come before it will give first consideration to maintenance with a view to conserving all the highways already completed if possible.

Reconstruction will be favorably considered by the council only where it is clearly established that maintenance is no longer possible except at prohibitive cost.

New construction will be given consideration by the council in the following relative order of importance:

(1) Highways and streets of military value.
(2) Highways and streets of national economic value.
(3) Unfinished contracts involving contractural obligations (incurred prior to April 5, 1918, where bond issue is involved) which may not be disturbed without serious consequences.

(4) Streets and highways which although not of national economic importance are of such extreme local importance or the construction of which has progressed to such a point as to cause serious hardship if their construction or completion is postponed.

The council is hopeful that the selective consideration of new highway and street construction by the township, county, and municipal officials and in turn by the State highway departments, will so materially eliminate the less essential projects as to make it possible for the council to render active aid on the projects it approves. The aid contemplated will be in the form of such action by the other government agencies involved as will remove obstacles to the speedy completion of the projects.

3. By way of definition of highways of military and national economic value, the council offers the following:

(*a*) A highway of military value is one used regularly for the transportation of military supplies in considerable quantity; for the movement as an established practice of Army truck trains, or which is essential to the efficient operation of a military cantonment, post, or plant.

(*b*) A highway of national economic value is one which serves or will serve, if properly improved, directly to promote the welfare of the Nation and not merely the local welfare. As examples, it may be stated that in this class would be placed (1) highways which although not directly used for military purposes yet serve to help win the war by greatly facilitating the output or movement of war munitions and supplies; (2) highways which can clearly be shown to relieve congestion on railroad lines in a territory which is actually in need of such relief; (3) highways which give access to or promote the output of natural products needed by the Nation to a marked degree; (4) highways which further housing operations undertaken by the Federal Government or by other agencies with the approval of the Federal Government would justify at times this designation.

4. State highway departments are requested to give most careful consideration to each application on its merits in the light of the policy announced by the council and to exercise the power of disapproval freely. Only the projects approved by the State highway department will be considered by the council unless the department itself is in doubt and wishes a decision in the nature of a precedent.

5. The council will shortly begin, in cooperation with the Bureau of Public Roads of the Department of Agriculture and the State highway departments of the several States, the preparation of a program of road and street construction, reconstruction, and maintenance throughout the United States for the working season of 1919. The purpose of the program is to obtain an approximation of the character and amount of street and highway work deemed essential in 1919, together with an approximation of the amount and character of financing required, the amount and character of the various materials entering into the work, the extent to which rail and water transportation will be involved, and the probable demands upon the labor supply. The preparation of the program in each State will be directed by the State highway department, and will cover all State, county, township, and municipal highway and street work.

6. For the information of the State highway departments as to procedure, forms are attached as follows:

Form H. C. 3, application to United States Highways Council for approval of project. This form should be filled out and signed by the public officials who are seeking approval of the project, and should then be filed with the State highway department. If the State highway department approves the application, it enters appropriate recommendation and certification on the last sheet of the form and transmits the application in duplicate to the United States Highways Council. The application is then given a serial number and its receipt acknowledged. It is then considered by the council and appropriate references made to the respective Government agencies interested. The applicant and the State highway department are duly advised as to action taken.

Forms F. 1 and F. 2 comprise application for approval of delivery of bituminous materials and certification of the application by the State highway department. These forms have been superseded by Form H. C. 3, but may be used if so desired where only bituminous materials are required.

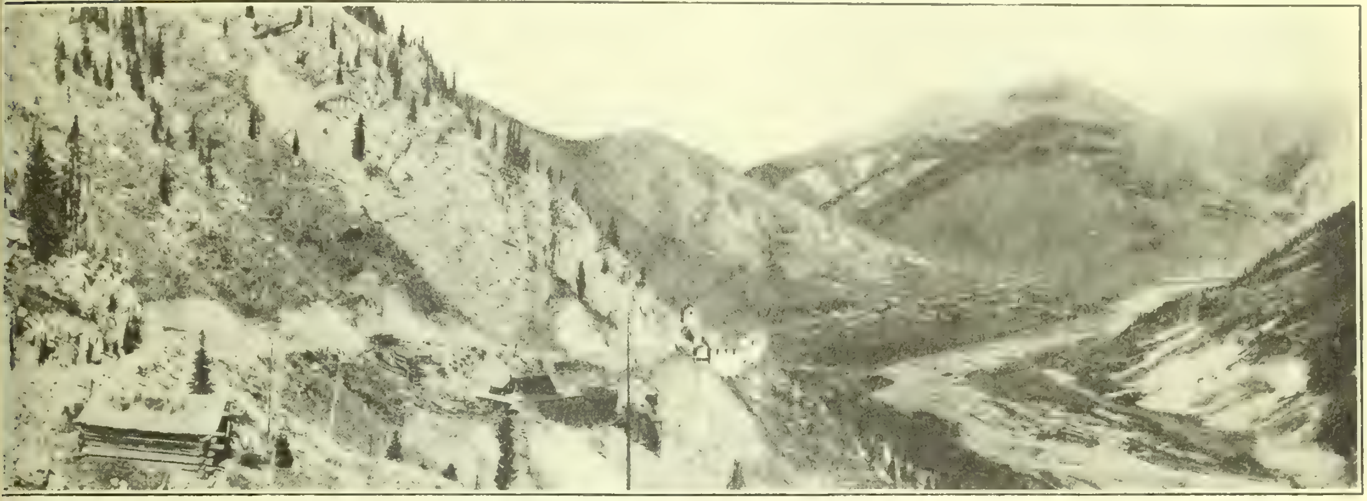
Form H. C. 4, schedule for use in submitting program of proposed highway and street work during the working season of 1919. This schedule is to be made up in four groups, namely: (1) State; (2) counties; (3) towns, townships, or districts; and (4) municipalities. For each of these groups three schedules, respectively, construction, reconstruction, and maintenance, are to be submitted. Definitions of construction, reconstruction, and maintenance, respectively, are given on form H. C. 4.

Announcement of June 20, 1918, a brief summary, giving organization, and purposes of the United States Highways Council, and showing the relation of various organizations represented on the council to highway work.

Circular No. C. S. 13, United States Railroad Administration, rules promulgated to govern car supply for stone, sand, and gravel, showing conditions under which open top cars may be supplied by railroads and providing for application to the Director of the Bureau of Public Roads, United States Department of Agriculture, where local car supply is insufficient. The representatives of the organizations mentioned in paragraph 5 of this circular comprise the United States Highways Council.

THE LOCATION AND BUILDING OF ROADS IN THE NATIONAL FORESTS.

By ARTHUR E. LODER, Assistant Chief Engineer, Bureau of Public Roads.



SILVERTON END OF THE DURANGO-SILVERTON ROAD, DURANGO NATIONAL FOREST, COLORADO, NOW UNDER CONSTRUCTION BY DAY LABOR.

THAT the national forests must play an important part in the road system of the United States becomes apparent when it is realized that the boundaries of the 147 national forests inclose a domain of 274,000 square miles, equivalent to the area of the States of California, Oregon, and one-fourth of Washington. This fact is driven home more forcibly when it is noted that instead of being grouped in one continuous area of regular proportions the forests are generally of an elongated, irregular shape covering the divides and rugged slopes of most of the mountain barriers which separate valley communities and stand in the way of interstate and transcontinental travel. As if to increase resistance the mountain ranges, and, therefore, the forest areas, generally lie along lines running north and south, while the larger portion of interstate travel passes in an east-and-west direction from its terminals at the seaboards.

Improved modern means of highway travel which make longer trips possible and the more intensive development of agriculture and all other resources of the valleys, create an ever-growing demand for roads through the forests on local as well as transcontinental routes. This demand will continue to increase at an accelerated rate.

In order to mold the current undertakings into a predetermined system, a list of projects giving the approximate location, length, and mileage of the principal roads considered by the Forest Service to be necessary for the present and future development of the national forests and contiguous territory has been prepared based upon estimates furnished by the Bureau of Public Roads and any other available data. This is known as the "comprehensive road plan" and gives some idea of the work ahead if the forests are to be made reasonably accessible and provision made for through travel. The latest compilation of this constantly growing plan shows a total of 785 projects to be built, aggregating 17,000 miles of forest roads. Although estimates are not yet available on about 4,000 miles included in this total, it is apparent that the ultimate cost of the system will be not less than $50,000,000 if built under normal conditions. This will require at least $25,000,000 of Federal funds, provided 50 per cent cooperation is secured throughout, or $15,000,000 more than the present act provides.

DEMAND FOR ROADS WILL INCREASE.

The undertaking appears large, but its ultimate accomplishment can not be doubted, since the demand for these roads will gather momentum rapidly as the present improvement gets under way.

The first "timber land reserve" was created by proclamation of President Harrison in 1891 and the Forest Service of the Department of Agriculture was created in 1905. No funds were provided, however, for systematic forest road work until 1912, when a beginning was made on road and trail construction under an act of Congress making available for that purpose 10 per cent of the funds derived from the sale of forest products. This is known as the "ten per cent fund."

Previous to this time the forest officials had appreciated keenly the need of trails and roads and had done considerable work in a small way on isolated projects in order to extend or connect existing trails and bridge a few streams which could not be forded by pack trains. Some assistance was secured from local road officials, timbermen, and graziers. This work was at times very discouraging because of the difficulty of securing the funds needed for explosives and materials and the necessity for performing the work by the labor of forest rangers in the winter or off seasons.

This small beginning, however, showed the necessity for work on a larger scale and resulted in the origin of numerous plans for the improvement of roads and trails in the forests. As early as 1906, at the request of the Forest Service, the Bureau of Public Roads assigned a highway engineer to cooperate in making a study of road and trail conditions in one of the national forests with a view to planning improvements. As funds were not available little was accomplished at that time except to show the need of funds and a vigorous prosecution of a road program in the national forests.

ROAD SYSTEM NECESSARY.

A system of roads was found to be as necessary for the national forests as for settled communities. They were required for the general administration of the forests; for fire protection and the rapid transportation of fire fighters; for the development of agricultural areas and mining camps within or adjacent to forest areas; for opening intercommunity or transcontinental routes of travel and the making of the forest areas available for the greatest possible recreational use; for the transportation of United States mails and to provide a means of defense in the event of military operations.

For the first two years after funds became available in 1912 the road and trail construction was carried on by engineers of the Forest Service. The money was allotted in small sums to many scattered projects and a large mileage of surveys was made, with the expectation of encouraging local road authorities to extend the short sections of improvements begun with Federal funds. Desired results were not being obtained and this policy was soon changed. The undertakings were cut down to a few of the more important pieces of improvement in each forest district in order to concentrate expenditures and secure earlier completion.

In 1914, upon the request of the Forest Service, an experienced highway engineer of the Bureau of Public Roads was assigned to five of the western forest districts to advise and assist the district foresters in road and bridge work and furnish the engineering supervision for the work within the district. Similar work in the Missoula Forest district was handled by a Forest Service road engineer. With further concentration on the more important projects a good beginning had been made on the construction program in each district at the close of 1916.

FIRST SECTION OF SEDALIA-DECKER SPRINGS ROAD, PIKE NATIONAL FOREST, COLORADO. WORK DONE ENTIRELY WITH ROAD GRADER.

COOPERATION BRINGS RESULTS.

Under this system the mileage of reconnaissance and location surveys was extended and a considerable number of construction projects were carried on within the national forests. In the five districts to which representatives were assigned the surveys were made either by the highway engineer representing this office or under his direction. Construction work was carried on by the Forest Service forces under the supervision and guidance of the Bureau of Public Roads representatives. Notwithstanding the small funds available much good was accomplished by this cooperative arrangement. More satisfactory results have been obtained through an arrangement whereby the responsibility of each bureau is more definitely established, and through the better class of engineering supervision which the larger construction projects permit.

The Federal-aid road act was passed in 1916. Section 8 of the act makes available the sum of $1,000,000 annually for the period of 10 years for

ROAD THROUGH THE CRATER NATIONAL FOREST, OREGON.

the survey, construction, and maintenance of roads, trails, and incidental bridges within or only partly within the national forests when necessary for the use and development of resources upon which communities within and adjacent to the national forests are dependent. The act provides that the work under these funds be carried on under cooperative agreements with local authorities on a basis equitable to both parties. The rules and regulations, promulgated by the Secretary of Agriculture for the carrying out of the work under the act, provide that the cooperator shall contribute for expenditure by the department at least 50 per cent of the cost of the work and also the entire cost of maintenance on roads constructed under the act, unless a satisfactory showing be made that such amount of cooperation is inequitable. This in effect makes available for the construction of so-called "section 8" national forest roads slightly more than $2,000,000 annually and, in general, relieves the Government of the cost of maintenance of roads constructed under the act.

RESPONSIBILITIES FIXED.

The establishment of a complete Federal highway engineering organization throughout the country was made necessary by that portion of this act providing $75,000,000 of Federal funds and at least an equal amount of State funds for post-road construction. For this reason, and in order to concentrate Federal highway engineering activities, the Secretary of Agriculture placed with the Bureau of Public Roads the responsibility for all engineering and construction work on the national forest roads and cooperative forest roads to be built under section 8 of the act. At the same time he placed with the Forest Service the responsibility for the general administrative work necessary in selecting the roads to be constructed, securing cooperation and cooperative funds, arranging the allotment of funds and financing of projects and, in general, harmonizing the scheme of road construction with the requirements of the national forests.

Independent of the "section 8" funds there still becomes available to the Forest Service annually for road and trail construction located entirely within National Forest areas, the so-called "ten per cent" fund. This fund during the current year amounted to $350,000, of which approximately 60 per cent is allotted by the Forest Service for expenditure by the Bureau of Public Roads on surveys and road construction work on major projects, which usually are financed by an equal amount from cooperators, but which may, if desired, be constructed entirely with Federal funds. The remainder is expended directly by the Forest Service on the construction of trails and on minor road construction and maintenance projects carried on by the forest supervisors and their force of rangers under the direction of the district foresters.

WORK IS FACILITATED.

The reorganization of the forest road engineering and construction work along the lines above indicated went fully into effect January 1, 1917.

The procedure, so far as the Bureau of Public Roads is concerned, is practically the same on both the "ten per cent" and "section 8" work, except that all construction and engineering under the "section 8" work is handled by this office while in the case of "ten per cent" work the Forest Service carries on the construction of trail and minor projects, and allots to this bureau only that portion of the fund to be used on so-called major projects which require handling in the same manner as the larger "section 8" projects.

The boundaries of the road districts, so far as the handling of forest road work is concerned, have been made to conform with the boundaries of the forest districts regardless of State lines, in order that each district forester may deal with only one district engineer. The national forests are largely located in the Western Mountain States and Alaska.

The forest road work of the Bureau of Public Roads in the six western forest districts is in charge of three district engineers under the supervision of the Washington office. Each district engineer handles the work within two forest districts.

PREPARE "WORKING PLAN."

Under the procedure recently perfected, the Forest Service and the Bureau of Public Roads in close cooperation prepare by States and districts during January of each year, and issue to the various offices concerned, the annual "working plan," which sets forth definitely the work to be done during the calendar year, and shows the exact allotments of funds to be made to each project and to general administration, as well as contingent allotments to take care of unforeseen expenditures or increase in costs. This plan indicates the administrative decisions by the Forest Service concerning the work to be done based upon estimates and reports of the engineers of the Bureau of Public Roads, in which this bureau shows the results of its investigations as to the labor supply and the practicability of carrying on construction work or the other activities under consideration.

The "working plan" is prepared principally in the field offices during an inspection by supervising representatives of the two bureaus. It shows by projects the work to be done during the calendar year on preliminary investigations, reconnaissance surveys, location surveys, and construction. Allotments of funds in accordance with this plan are made directly to the individual projects in case of survey and construction work and to the road district for overhead work and the preliminary investigations and reconnaissance surveys. This plan and system of allotments prevents the undertaking of work in excess of funds available and makes possible a businesslike planning of the season's work, so that funds will not be lacking to carry it out and cover all liabilities to the end of the season. From the "working plan" district engineers may lay out the season's work economically and determine the order and locations of assignments for the units of their engineering and construction organizations.

SECTION OF LAGUNA ROAD, CLEVELAND NATIONAL FOREST, CALIFORNIA. INEXPENSIVE TYPE OF CONTOUR ROAD.

WAR CONDITIONS GOVERN.

In preparing the plan for this year's work it became necessary to give first consideration to war conditions. This involved not only the effect which the present abnormal financial and labor conditions would have upon the conduct of the work but the effect which the construction of each project might have on the winning of the war. These considerations caused the volume of construction for the season to be reduced to a minimum. At the same time they caused the postponement of some surveys. It was considered, however, that so long as men might be found available it would be good policy to advance surveys and plans, in order that a larger volume of work might be in readiness at the close of the war in the event it then should be found desirable to increase public work and open up the forests and adjacent agricultural country during the period of readjustment which must follow.

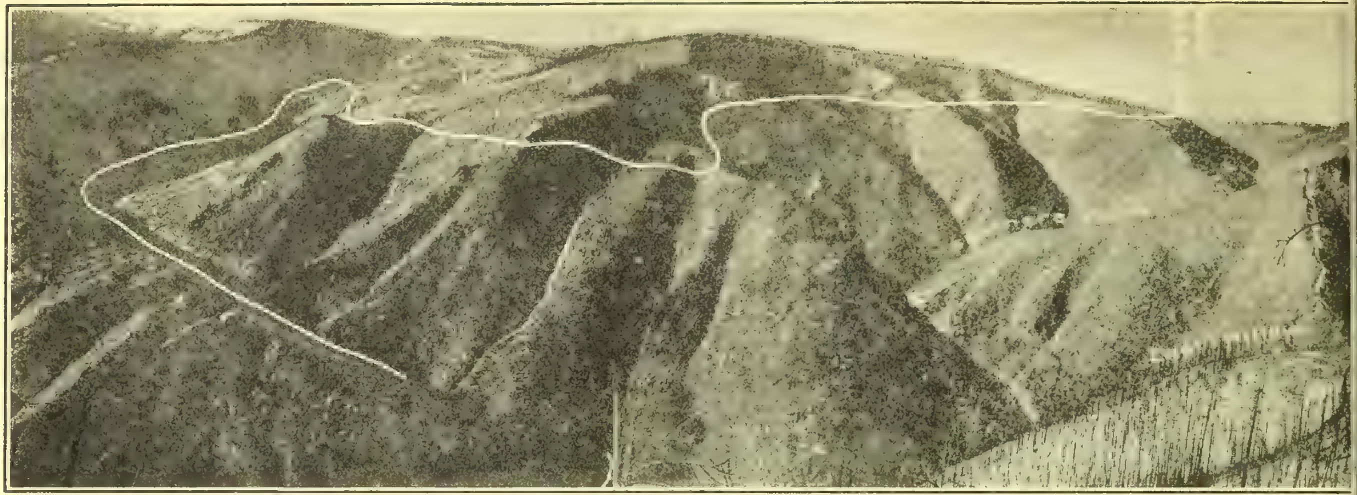
SWITCHBACK ON SECTION OF SEDALIA-DECKER SPRINGS ROAD, PIKE NATIONAL FOREST, COLORADO.

It was found that some projects would open valuable tracts of spruce timber needed in aeroplane construction, while others would reach timber resources required for shipbuilding and other construction affecting war industries. Certain roads would make isolated but very essential mining activities accessible to railroad transportation. Others would make possible the distribution of local coal deposits or firewood needed by valley communities and near-by towns to relieve the fuel and transportation conditions. Some projects would immediately open up rich agricultural areas and increase food production. Construction work was postponed on each project unless it would contribute in some such manner to war activities or could be constructed with local labor between crop and fire-fighting seasons without interfering with labor on essential war industries.

ELIMINATING UNLIKELY PROJECTS.

Preliminary engineering examinations or reconnaissance surveys of proposed projects under section 8 funds are made before cooperative agreements are entered into with local authorities for complete location surveys or construction. This prevents squandering funds on location surveys of roads before it is determined finally that cooperative funds will be available for construction. Under this procedure the location survey follows the making of the cooperative agreement, and causes the cooperator to share in the expense of the survey. Similar procedure is now employed in connection with most of the Forest road projects under the 10 per cent funds.

Before the adoption of this method, hundreds of miles of location surveys had been made with the hope of securing cooperation, which in many cases has since vanished, leaving the work of slight value



SHOWING RECONNAISSANCE SURVEY OF THE ALTERNATE ROUTES FOR THE WHEELER NATIONAL MONUMENT TRAIL THROUGH THE BURNED-OVER REGION RIO GRANDE NATIONAL FOREST, COLORADO.

to the future. A preliminary engineering investigation or a relatively inexpensive reconnaissance survey can be extended without great expense over a large mileage of proposed projects. This exploration or pathfinding not only furnishes estimates and data necessary for the working out of the general Forest road plan and for any desired cooperative agreements preparatory to construction, but at the same time eliminates impossible locations and indicates the general location to be followed later by the locating party, which may begin its work with confidence that the desired location can be carried through to the end of the line without loss.

PRACTICAL EXPERIENCE ESSENTIAL.

In this preliminary engineering work the one important consideration is the practical experience of the field engineer performing the work and his ability to visually compare the quantities and construction difficulties with other similar projects on which he may have made location surveys or handled construction. It is found that the qualifications of the man have more to do with the accuracy of his report and estimate than instruments or other means employed by him on the work.

One of the principal difficulties experienced with all estimates has been the rapid increase in the cost of work and inability to forecast costs which are still soaring.

PRELIMINARY AND FINAL SURVEYS.

Only preliminary investigation by the field engineer is made where the prospect of further work appears remote, and it is also used for the review of old surveys or preliminary lines which have been made by private parties or local officials. Under the more favorable conditions the estimates from this type of work can be used in cooperative agreements without a further reconnaissance. As a rule, however, the preliminary investigation is not made if the chances are good for a cooperative agreement in the near future.

Cooperative agreements are generally based upon so-called reconnaissance surveys, the work of which is more intensive than the preliminary investigations. An effort is made to secure an estimate within 25 per cent of final quantities. This may be done by the experienced man with comparatively little instrument work, while the estimates of less experienced men will more often fall outside of this limit regardless of elaborate observations, notes, plans, or computations.

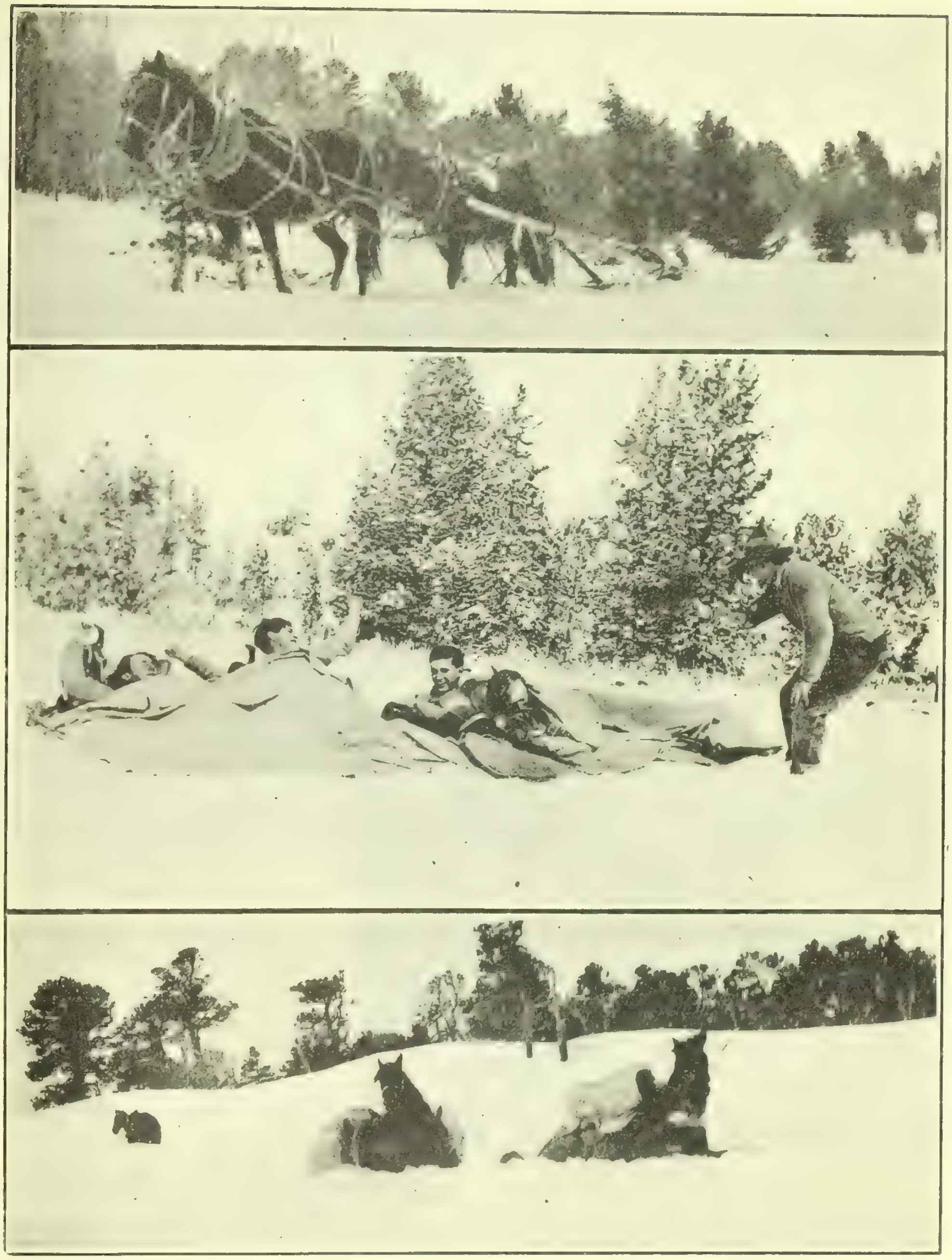
After a cooperative agreement has been entered into and the project has been financed, location surveys are made in the usual manner.

In order to meet constantly rising costs and the serious shortage of men of experience it has been found necessary to reduce the survey and plan work to the simplest possible terms consistent with economical location and design and in keeping with the proposed construction expense. In some cases where construction is light and location conditions are easy the survey and plan work will resemble the so-called ''preliminary survey'' of railroad practice. The relative experience and efficiency of the locating engineer is found to affect the cost of the survey and plans by a large percentage. In some cases on less important roads and under favorable conditions it has been possible to construct from an intensive reconnaissance survey without further instrument work.

During the season of 1917, which was the first following the reorganization of forest road work in accordance with the new act, a considerable length of time was required in most districts for the negotiation and execution of desired cooperative agreements before the Bureau of Public Roads could be authorized to make surveys preparatory to construction. While a few location surveys could be started early, the bureau was not in receipt of authorization to begin work on the majority of them until after the middle of the working season.

WAR CALLS THE ENGINEERS.

A large proportion of the experienced field ngineers of the organzation answered the irst call of war and ntered officers' training camps. Many of he younger men rolled heir blankets and prepared to follow, making t necessary to recruit new survey parties as he work materialized. Available men with vestern mountain road xperience became rare s soon as road building nits began to be organized for overseas ervice. It was a high rivilege to furnish road uilders to become offiers who are now takng active parts in uilding the "road to Berlin." It was, however, a task to organize nd train temporary nd relatively inexperienced survey and ield men to be sent ut on a few days' notice on mountain road urveys. As many nen as possible with vestern experience were secured. It became necesary, however, to supply a considerable number rom the east where road building organizations vere suspending work.



TOP AND BOTTOM—TRANSPORTING MAILS IN WINTER ALONG PROPOSED PROJECT, SHOSHONE NATIONAL FOREST, WYOMING. CENTER—OPEN-AIR LODGING FOR A SURVEYING PARTY.

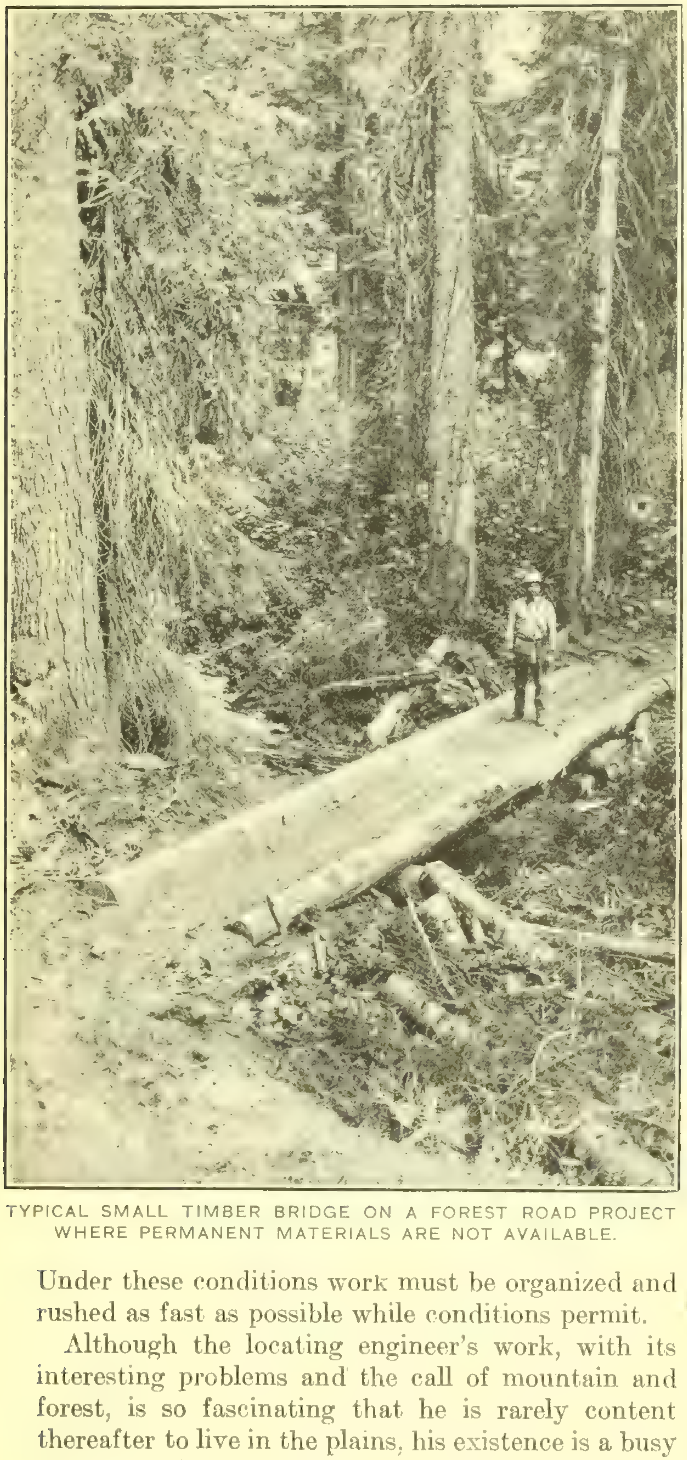
Although no surveys on section 8 projects could e completed in time for beginning construction last ear, good results were obtained considering conditons and the work is progressing this year in a more atisfactory manner as greater experience has been ained in the selection and placing of men who are ot so likely to be called or accepted for military ervice.

FOREST ROAD SURVEY WORK.

During last season and until July 1 of this year, he following number of projects and mileage of rest roads had been surveyed by the office:

	Miles.
Sixty-four preliminary investigation projects	1, 574
Fifty-six reconnaissance survey projects	1, 146
Thirty-nine location survey projects	795
Total mileage all classes survey	3, 515

Much of the work is located at high altitudes where heavy snow remains until late in the spring. The streams carrying away the melting snow remain at flood stage making them difficult to ford until the last of June and in some cases even later. In such places the snow may begin to fall again in September and often stops field work before October. Although the work is located in every climate from the torrid desert, through regions of excessive rainfall and high timberline altitudes to the frozen forests of Alaska, the average season for efficient work is short.



TYPICAL SMALL TIMBER BRIDGE ON A FOREST ROAD PROJECT WHERE PERMANENT MATERIALS ARE NOT AVAILABLE.

Under these conditions work must be organized and rushed as fast as possible while conditions permit.

Although the locating engineer's work, with its interesting problems and the call of mountain and forest, is so fascinating that he is rarely content thereafter to live in the plains, his existence is a busy one and his hardships real. He soon learns to regard as a luxury his bed made by pounding the earth with an ax to remove the stones and roughest projections, and never has difficulty in sleeping without shelter unless the coyotes howl too much. He is also content with his morning bath in an icy stream and never complains of an all day and night hike to find camp, but the romance of the work gives way to the most serious problem of existence when, on a long lonesome reconnaissance a week's travel from base, he wakes in the morning to find that a neighborly bear has visited camp, destroying hi light grub pack and making away with the baco upon which he had relied for subsistence on hi return journey. If to this is added the sadness o finding that his horses have slipped their hobble and disappeared completely, leaving him afoot hungry, and four days from grub, his misery i complete. When a survey party sets forth with standard camp, living conditions are usually goo The hardships are more often encountered on th long reconnaissance surveys when an attempt i made to travel with little equipment, dependin upon game and good fortune for subsistence. Som sections can be traversed more easily by waiting fo snowfall and using snowshoes or skis. In Alaska th dog train is useful. It is not an uncommon experience for the party to bunk in the snow withou tent.

Occasionally the survey must be carried along th face of precipitous slopes and rocky cliffs where misstep or a loosened rock would be disastrous. I such cases long ropes from above suspend the me or protect them from accident. In 1916 one member of a survey party on this work lost his life fro a fall of several hundred feet on account of n taking such precaution.

LOCATING ROADS IN THE MOUNTAINS.

The selection of a location for forest roads i mountainous regions is influenced by a number considerations in addition to line and grade. Th geological formation may become a deciding facto while it always has an important bearing upon co of construction and maintenance as well as t safety of the road for traffic. A study of the formation is not only necessary in estimating the classific tion of excavation, but in order to so locate that aft construction the cut slopes and fills will safely wit stand erosion and displacement. Dangerous grou must be avoided.

Trouble may result from the sliding of unsupport rock strata on steeply inclined beds lubricated wi with talc or clay-like materials. Irresistible la slides of wet earth varying in size from very sm areas to hundreds of acres in extent may carry aw entire embankments or close cuts until their maint nance would become very discouraging if not i possible. Such slides may carry the road out position only a few feet in a year's time or may ov night carry away all trace of the road with the effe of an avalanche.

In one case a reconnaissance survey and study the underlying formation showed that it would considerably cheaper and result in a more satisfa tory roadbed to adopt a location following a rugg canyon, where considerable quantities of rock excav tion would be required in preference to an alterna

SURVEYORS' CAMP AMONG THE FERNS IN OLYMPIA NATIONAL FOREST, WASHINGTON.

route over easy rolling highlands where excavation quantities would be less. The easy appearing location was found to be the more expensive one due to the fact that the road would extend for miles over the immediate surface of a thick strata of tough sandstone requiring small excavation quantities, but unusually high unit costs because of the shallow cuts and the nature of the rock, while the canyon route passed generally through the rock débris slopes below limestone cliffs underlying the sandstone formation which appeared at the rim of the canyon. The last location, although requiring the excavation of larger quantities of rock, was found to be the less expensive due to the lower unit costs. The limestone also afforded an excellent road surface.

Preference is usually given to the slope which is most exposed to the sun. The rock formation on such an exposure is usually more disintegrated, and therefore weathered down to an easier slope which will require less expensive excavation. The warmer slope will usually be closed by snow for a shorter season and presents fewer subdrainage problems.

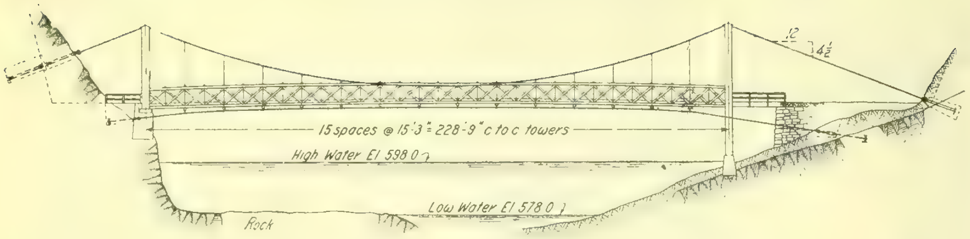
SINGLE-TRACK ROADS CONSTRUCTED.

Because of the limited funds the building of forest roads frequently becomes a question of "getting through" and establishing communication with an unsurfaced narrow road, which will open up the country and serve as a beginning for further construction as conditions make possible. This requires that the grades be laid out with a view to future development in order that it may be necessary only to widen the roadway and at the same operation improve the alignment at the sharp points.

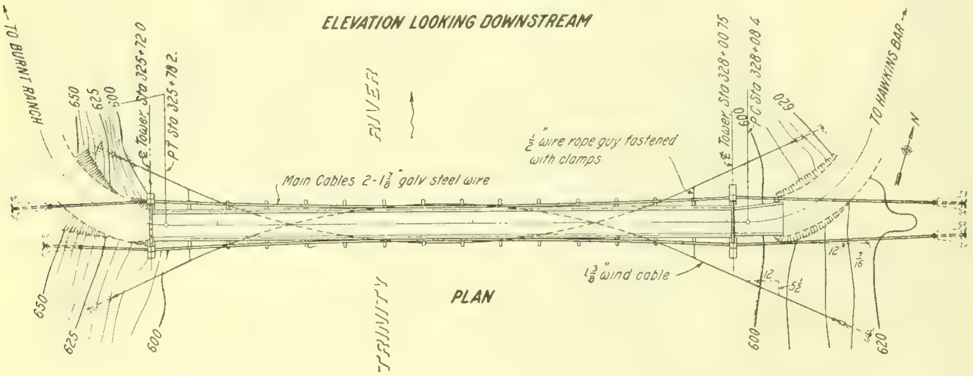
If a single-track road is used, frequent turnouts are provided at such points that approaching traffic may be seen after it leaves the first turnout ahead. These narrow roads are constructed on lateral routes or inter-community roads on which it is not expected that heavy travel may set in at once.

Even on a road which is to serve as a connecting link of an important through highway, insufficient funds occasionally make it necessary to construct a single-track road on short expensive sections. Such a road, well maintained, safeguarded, and provided with ample turnouts, can handle a relatively heavy mountain road traffic which is more uniformly distributed throughout the day than on roads near thickly settled communities.

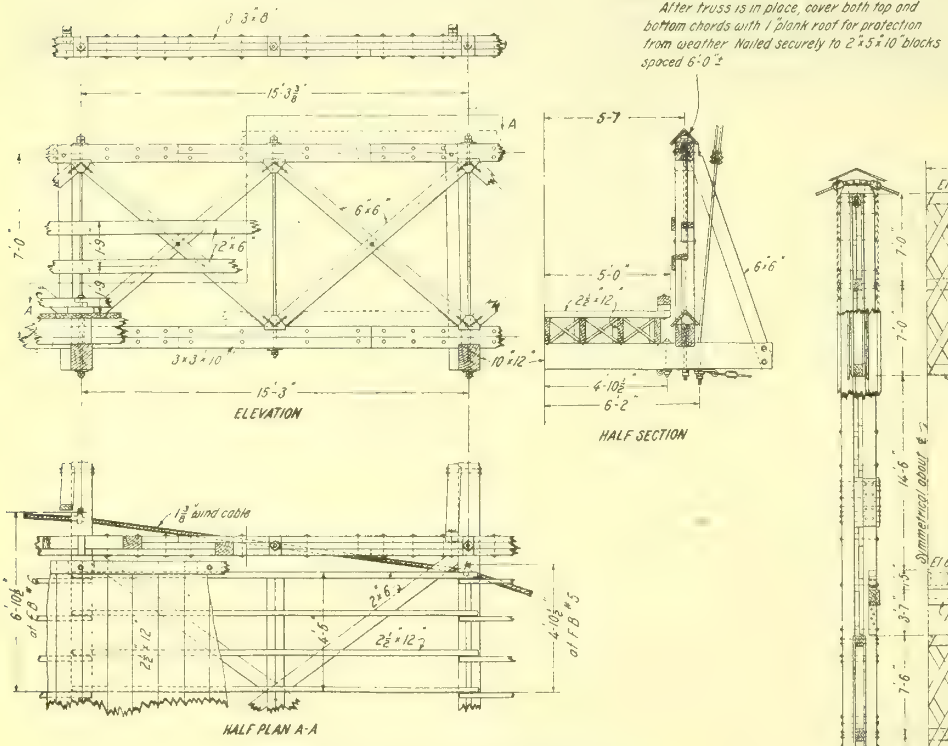
On the more important routes double-track roads are built whenever possible. The widths depend upon the cost of excavating and the durability of the material, the safety of the road along the edge of fill, and the general difficulty of construction. It is economy to avoid the building of intermediate



ELEVATION LOOKING DOWNSTREAM

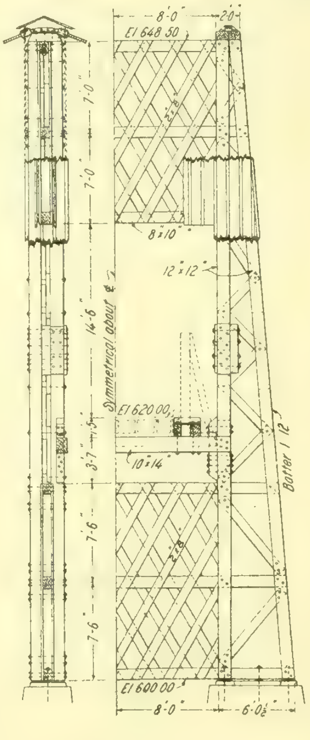


PLAN



Note: After truss is in place, cover both top and bottom chords with 1" plank roof for protection from weather. Nailed securely to 2"×5"×10" blocks spaced 6'-0" ±

TYPICAL INTERIOR PANEL OF STIFFENING TRUSS



DETAIL OF EAST TOWER

GENERAL NOTES

Placing the cables. Concrete the cable anchors firmly int the solid rock walls of the canyon, taking care to place the rods in line with the cable, as shown Allow concrete to se two weeks (temperature above 40°) before cables are swung into place Sockets should be so located on cable th the elevation of the cable at the center of span under its own weight will be 3" higher than that shown on the eleva tion, while the adjustable anchors are at mid position (s as to allow for future adjustment either way)

Housing of towers. Entire timber framework of towers be housed for protection from the weather, by shakes, shi gles, or 1" sheathing securely nailed to proper planking so a to allow a space of 4" between housing and plane of post

Wind load cables. Cables to be of 1⅜" galv wire rope having ultimate strength of 150,000 lbs Cables to be an chored firmly to walls of canyon, same as main cables.

Stiffening trusses. Panel lengths specified for top and bottom chords should be strictly adhered to in order to pro vide the camber of 1'-9," which camber (together with prope adjustment of hangers) will give the elevations of roadway at panel points as shown in general elevation

East approach span. Use 20 ft stringers supported at east end by masonry abutment or rock fill Use 3"×12" string ers @ 18" c to c or 2½"×12" @ 15" c to c Provide suitable guard rail of 4"×6" posts and 2"×6" rails Widen roadway to 14'-0" at abutment end

Timber (except hard wood blocks) to be fir, for which the following stresses are used:

Bending, extreme fiber stress	1500 #/□
" , longitudinal shear	100 "
Compression, perpendicular to grain	200 "
" , cols, $\frac{L}{D}$ not over 10	1000 "
" , " $\frac{L}{D}$ values 10 to 30	1200-20
Tension	1500 "

Hardwood blocks to be of good quality white oak or live oak

Live loads: One typical 5-ton truck, or 50 lbs per sq uniform load

Impact allowance, 30% of live load

Dead load: 500 lbs per lin ft of bridge

Wind load = 30 #□' on twice projected area

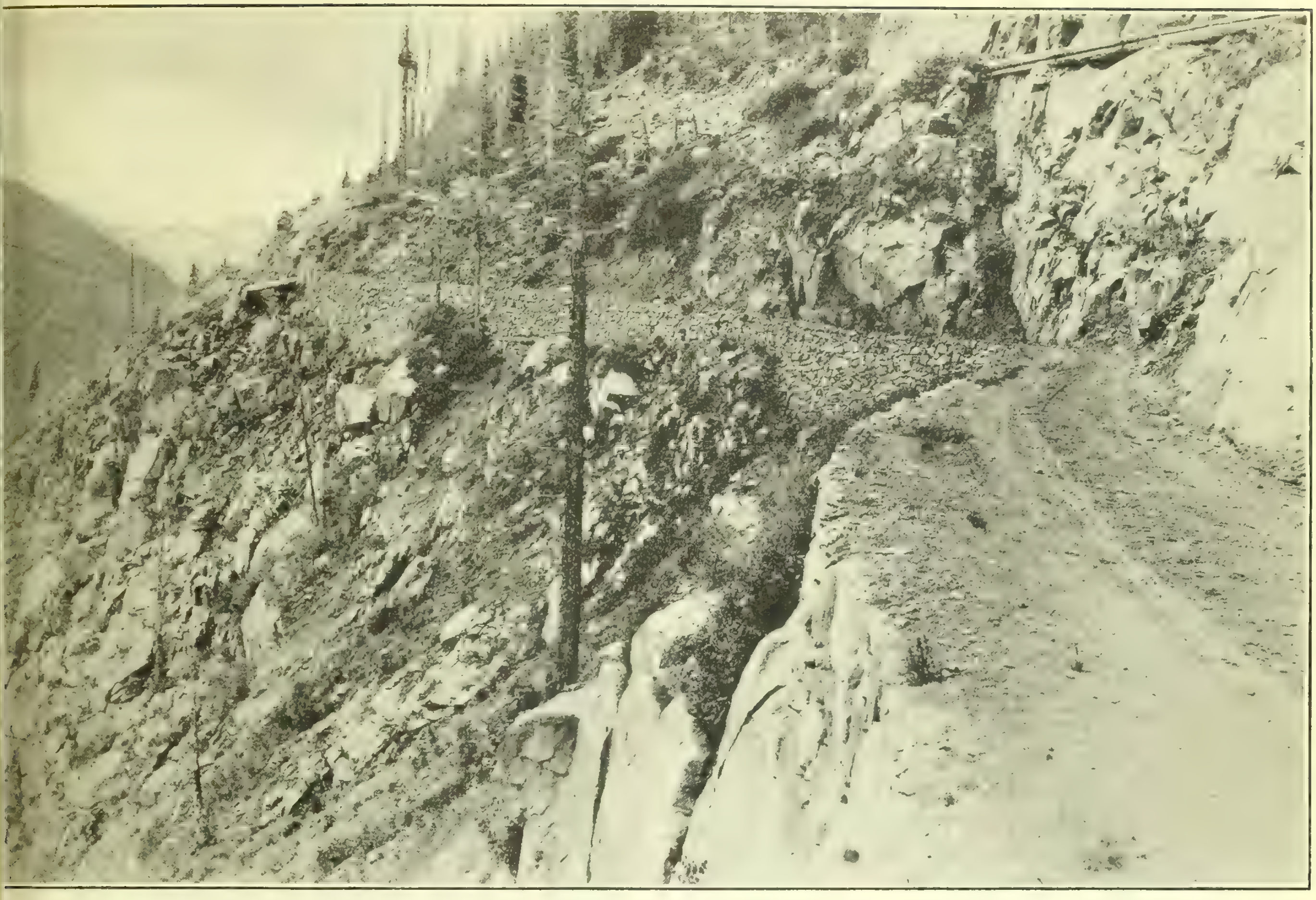
Max stress in cable = 167000 lbs

All concrete 1 3 6 mixture

BUREAU OF PUBLIC ROADS
WASHINGTON, D C

LAYOUT AND PLAN
SUSPENSION BRIDGE
OVER
TRINITY RIVER-HAWKINS BAR R
TRINITY NATIONAL FOREST
TRINITY COUNTY
CALIFORNIA
1918

CORRECT O L Grover BRIDGE ENGIN
APPROVED CHIEF ENGINE



TYPICAL SECTION DURANGO-SILVERTON ROAD, DURANGO NATIONAL FOREST, COLORADO, SHOWING RETAINING WALL.

widths which are wider than necessary for a single-track road and too narrow for double-track.

DRAINAGE AND STORM PROTECTION.

Rain and snow fall more heavily and for a longer period in the altitudes at which these roads are generally located than in the valley regions. This requires special attention to surface drainage and storm protection. The cross-section of gutter ditches is varied with the volume of water and the nature of the soil. When there is little water to be carried the gutter is decreased and so graded that it may serve as a portion of the roadway. This is possible when cutting through rock or durable materials which are not readily softened by the gutter water. Such variations of width result in considerable savings in excavations on expensive sections of road.

Notwithstanding the fact that pipe culverts are placed at frequent intervals to carry the gutter water across the road, it is necessary in many places to make the gutters wider and deeper than would be used on the average State highway. Deep snow drifts form along the cuts and in the gutters. When the snow melts the rate of run-off is very high and the gutters are obstructed by the drifts which tend to throw the water across the road where, if concentrated, serious damage may result. Wherever practicable slope ditches are used above the top of cuts to divert the water coming down the hillside into culverts. This relieves the road side gutters, facilitates the rapid removal of melting snow from the slopes above and often results in a saving of quantities by reason of the decreased width of road section which can be used in cuts.

After fills become settled the most dangerous points along the road are protected with a heavy rustic guardrail or rough stone wall.

Although primarily constructed for low-speed traffic, it is found that the maintenance of forest roads is decreased and traffic safeguarded by slightly superelevating curves sharper than 300 feet radius in order that approaching vehicles may keep to the proper side of the road with safety.

BRIDGE AND CULVERT WORK.

Permanent bridges and culverts of standard design are constructed when funds and materials are available. However, it frequently becomes necessary to use timber or such material as may be at hand. Under present conditions the use of steel is avoided as far as possible. The long distance from railroad generally makes concrete very expensive. In many cases part of the structures must be placed in advance of the grading and therefore considerably in front of any available wagon road. The materials must then be carried on pack horses over steep trails unless local timber or stone is used. Under these conditions structures of the types shown in the accompanying illustrations are constructed of peeled logs up to clear spans of 70 feet.

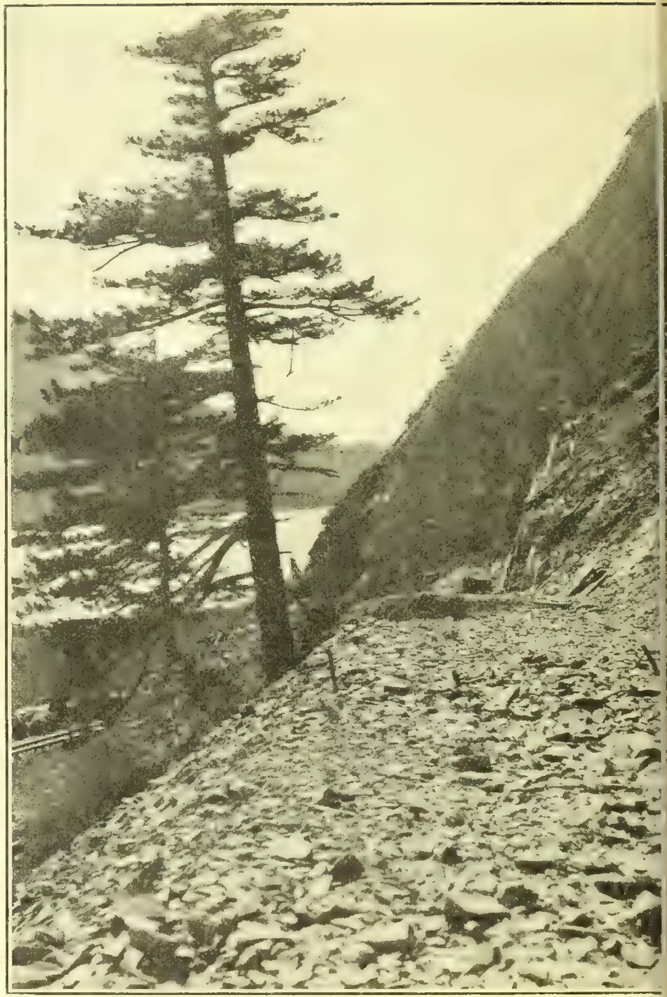
In a dry climate and when using species of timber selected for resistance to decay timber structures are found to have remarkable endurance and are believed to be more economical in some cases than permanent structures, notwithstanding their renewal and maintenance cost. This condition prevails, especially if the timber structure is so built that it can be renewed without seriously interrupting traffic and is located where danger from fire is small.

SUSPENSION BRIDGES OVER CANYONS.

Suspension bridges which can be constructed with the labor and equipment at hand are found to be economical and well adapted to some of the deep canyon crossings of rivers in the national forests. Many bridges of this type are found in or adjacent to forest areas ranging from the crudest homemade foot bridge of barrel staves woven into twisted fence wire or light cable, which gives the sensation of tight-rope walking, to the modern suspension bridge built after good engineering designs. Some unique old bridges of this type, built with inadequate stiffening trusses and poor wind anchorage, are found on old trails. In fact, the stiffening trusses are usually neglected to a considerable degree.

The accompanying drawing shows a suspension bridge being built this season by the Bureau of Public Roads over the Trinity River, Cal., on the Hawkins Bar project. It is on a spur road to reach limited forest products, and is of necessity a very light bridge. In fact the withdrawal of some of the allotted funds and difficulty in securing the required cable under war conditions made it necessary before beginning construction to decrease the loading from a 5-ton to a typical 3-ton truck. The stiffening trusses shown in this design should provide a rigid floor system under traffic. The bridge is secured against wind action by a pair of opposed wind cables placed below the floor and adjusted to secure lateral stiffness by pulling against each other throughout the length of the bridge, the wind stresses being carried to the shore anchors without affecting the towers.

Such bridges lend themselves to forest road and trail work from the fact that only the cable and a few rods must be imported. A long, heavy cable can be carried from the railroad for many miles over narrow trails on the backs of horses, forming a continuous pack train winding its way through the timber and along steep or crooked trails.



WIND MOUNTAIN SECTION, COOKS-COLLINS ROAD ALONG NORTH BANK OF COLUMBIA RIVER, WASHINGTON, SHOWING CONSTRUCTION AT BEGINNING OF THE SECTION WHERE HIGHWAY MUST BE BLASTED THROUGH ROCK CLIFFS OVERHANGING A HEAVY TRAFFIC RAILROAD, CONSTRUCTION NOW UNDER WAY BY DAY LABOR.

TWO ROADS ADD TO USE OF FOREST.

Comparatively little construction was financed and ready to be undertaken during last season, except work initiated under the old 10 per cent fund. The Laguna road, 14 miles in length, in the Cleveland National Forest, California, was constructed by the office from this fund, and its completion has opened up considerable forest resources, at the same time making this attractive forest available for the recreational use of the people living in the hot interior valleys. Visitors may now enjoy the refreshing breeze from the Pacific and at the same time obtain magnificent views of the country to the east in the vicinity of the Salton Sea and the Imperial Valley.

Construction has been completed this season on the last section of the Teton Pass road which connects the Jackson Hole in Western Wyoming with the outside world by way of Victor, Idaho. This will make possible the hauling of agricultural and forest products over a road which has heretofore been a serious barrier to traffic.

The construction of a 5-mile section of the Trinity River road in the Trinity National Forest is being carried on by day labor, extending a road previously built by this office. It is also expected that some construction will be done this season on the Heber-Fruitland and Ephraim-Orangeville projects in Utah, if labor can be secured.

DIFFICULT PROJECTS UNDER WAY.

The Alberton project in Montana, along Clark's Fork of the Columbia River, with a length of 4½ miles, is now being constructed under contract, at a cost of approximately $62,000. This project will complete the worst remaining section in the main transcontinental highway across the northern Rocky Mountains extending through Montana and westerly by way of Spokane. The accompanying photographs show the beginning of retaining wall construction which permits the carrying of this road on a very steep slope between the Northern Pacific Railroad and the river. It is typical of a number of important forest road projects where it becomes necessary to construct a highway along a narrow canyon or gorge already occupied by a river and one or more railroads. Construction under such condition becomes expensive and requires considerable engineering investigation and care. The difficulties in this particular case are less than in other cases where the road construction lies above the railroad. In such cases the blasting and rock excavation must be conducted with the greatest care and at much expense to prevent wrecks and the tie-up of railroad transportation.

A similar project is the Cooks-Collins road in the Columbia National Forest, State of Washington, located along the northern bank of the Columbia River about 60 miles above Portland. This project is now under construction by this bureau on a day labor basis. It is located along a difficult section of the North Shore road and must, in general, be blasted out of solid cliffs in a narrow space above the railroad. The cost is estimated at about $96,000 for a length of 4½ miles. On the Wind Mountain section of this project. The work will cost at the rate of $60,000 per mile. High and expensive dry rubble walls must be built to support the road. The completion of the project will extend a road up the Columbia Bank road which was previously constructed to this point by the State of Washington.

An effort was made to construct by contract this season the Quinault Lake road in the Olympic Peninsula in Washington in order to facilitate hauling spruce timber from the forest to the nearest railroad station. It was impossible to secure bids within reason and it is expected that the worst portion of the road will be constructed during the season by day labor if laborers can be secured.

"CEDAR BREAKS" ALONG THE CEDAR-DUCK LAKE ROUTE, SEVIER NATIONAL FOREST, UTAH. SCENERY SECOND ONLY TO THE GRAND CANYON.

The Flora-Enterprise road, 12 miles in length, in the Wallowa National Forest in northeastern Oregon is to be constructed during the season by day labor after failure to receive bids for the work.

FOURTH OF JULY CANYON PROJECT.

Construction under contract has been started this season on a 12-mile section of the Fourth of July Canyon project near Coeur d'Alene, Idaho. This section is estimated to cost $140,000. It is, in part, located along the shore of Lake Coeur d'Alene and will open up for through travel probably the worst section remaining in Idaho on the northerly transcontinental route crossing the Rocky Mountains by way of Missoula and Spokane.

Following the travels of Lewis and Clark, the importance of this great northerly route across the Continental Divide caused Congress to appropriate $10,000, with which Capt. Mullen, of the United

States Army, undertook the survey and construction of the first wagon trail across this region. On July 4, 1861, his survey had progressed as far as this project, where he blazed a tree, upon which he inscribed the date. From this incident he gave the canyon its present name. So far as known, this is the only original monument in existence on the Mullen trail, although granite monuments have recently been established at other points through Montana and Idaho to mark its location.

The cost of road building, as well as the requirements of traffic, have indeed changed since 1861, as shown by the fact that each mile of this part of the old Mullen trail now being completed costs more than the amount given to the pioneers for the entire route.

Bids have been requested for the construction of the Sheep Creek and Yaak projects, in Montana, and for the Canyonville-Galesville forest road, which forms a section of the Pacific highway, in Oregon. However, in the light of recent experience on other projects, it is doubtful if bids will be obtained, making it necessary to resort to construction by day labor wherever it appears necessary to proceed with work.

CONSTRUCTION BY DAY LABOR.

Construction by day labor is now under way on the Durango-Silverton road, Colorado. This project is 53 miles long and estimated to cost $233,000. It appears to be one of the few projects where an ample supply of labor can be secured this season. The illustration on page 15 shows a typical section on one end of this road illustrating the character of construction which will be necessary on much of the work. This particular section was built under an earlier contract, but the road is to be widened at some of the worst points and the retaining walls reinforced as a part of the present project.

Construction is also to be carried on by day labor, provided sufficient forces can be obtained this season, on the three following forest roads in Colorado: Rabbit Ears Pass, length 9 miles, estimated to cost $20,500; Monarch Pass project, length 27 miles, estimated to cost $83,500; Sedalia-Decker Springs project, length 18½ miles, estimated to cost $36,400.

A 16½-mile section of the Deadwood-Hot Springs road in the Black Hills National Forest, S. Dak., is to be constructed this season at an estimated cost of $57,500, if labor can be secured.

In New Mexico it has been planned to begin construction this season on the following four projects: Tijeras Canyon project in the Manzano National Forest; the Cimarron Taos project, in the Carson National Forest; the Hondo-Mescalero project, in the Lincoln National Forest; and the Glorieta-Panchuela project, in the Santa Fe National Forest. These projects aggregate 56 miles in length and cost approximately $215,000. The present labor situation, however, makes it doubtful if much can be accomplished this season on these projects.

Construction has been completed this season on a timber trestle bridge across Cass Lake in the Minnesota National Forest, which will make possible a projected State highway route across Minnesota extending from Duluth on the lakes to a point on the Canadian line in the northwesterly part of the State.

Construction by day labor is now under way on the Ozark road in the Ozark National Forest, Ark., between Russellville and Pleasant Hill, at an estimated cost of $60,000.

An effort has been made to arrange for the construction of a number of other forest road projects this season. The supply of labor, however, is a serious handicap, and it is apparent that the proposed work of the season will of necessity be greatly curtailed, except in certain localities, where unfavorable crop seasons or other unexpected conditions have resulted in an adequate supply of local labor which is seeking employment. Contracting conditions have been so unfavorable that very few bids have been received.

Because of these conditions it has been necessary to resort to construction by day labor on many projects which were urgently needed but where contractors could not afford to take chances on bidding. Under the day labor method it would be possible to close down at any time without serious loss should it be found inadvisable to continue work. The temporary suspension of work would serve only to delay the proposed improvements for the time being, since the Federal funds remain available until expended.

The force account or the cost plus system will not be employed on any of these forest projects, since the conditions do not appear to warrant undertaking work on such a basis.

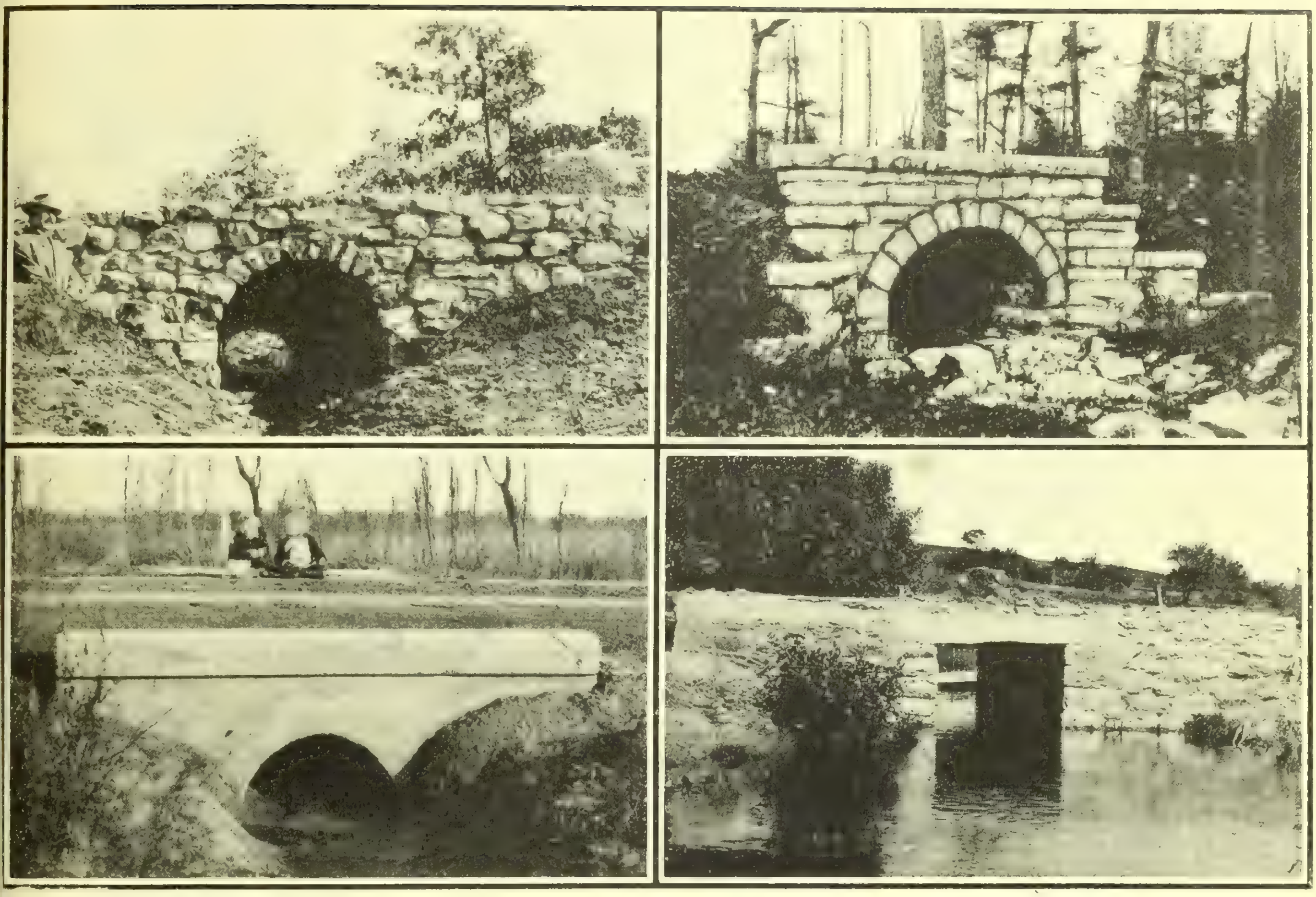
WAR BRINGS BRIDGE BUILDING BACK TO EARLY PRACTICES

By **O. L. GROVER**, Bridge Engineer, Bureau of Public Roads.

War conditions and necessities govern and must govern all our business and improvement activities. This will continue to be the fact until affairs are brought back to normal conditions after the close of the war. We can not get away from this.

Every road-building project, whether new construction or repair work, must be considered in its bearing on the war work of the country.

The elements affecting highway improvement under war conditions include the labor problem,



TOP, LEFT—BRIDGE AND CATTLE PASS, CALHOUN COUNTY, ALA., COST $250. TOP, RIGHT—STONE CULVERT IN CHICKAMAUGA PARK, TENNESSEE. BOTTOM, LEFT—HALF ARCH CULVERT IN POTTAWATOMIE COUNTY, OKLA. BOTTOM, RIGHT—CULVERT WITH FLAT STONE TOP AT BRUNSWICK, MAINE.

existing because of the steadily growing scarcity of the country's man power and the increasing demand for that power in war industries, and the limitation in the supply of materials needed in construction, due to both transportation difficulties and to inability of the manufacturers to produce them.

Road building and road repair work must be limited to the essentially necessary work, the construction of only such new roadways as are indispensable in the country's war work and the repair work demanded to keep the highways in usable condition.

Some additional construction may be carried on where local supplies of materials are to be had without taxing the railroad service and where the situation is such that labor may properly be employed on the work.

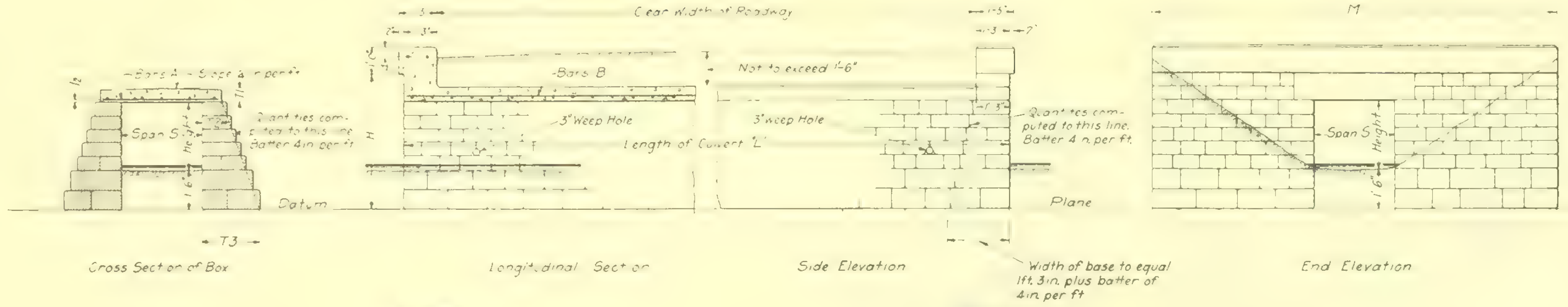
In highway construction attention is paid most often to the building of the road. Perhaps too little attention has been given to the building of bridges, a factor having an important part in the solving of the highway problem. In any construction work necessary under war conditions the bridge problem is likely to be equally if not more serious than that of the road making part.

In many communities culverts and bridges must be built, even under war conditions, to keep the highways in shape for use, even where no new road construction is under way or would be authorized.

MUST REVERT TO TIMBER.

Steel has been the favorite bridge material for several years. It has been used for small as well as large structures. At present steel is not available in any quantity for bridge construction. It can not be had at all where its use can be avoided, while all large steel construction necessarily must be abandoned or postponed until peace and normal conditions return. This situation forces the use of other material—timber, concrete, stone, and brick.

For long bridges and for temporary work where the cost must be kept down regardless of high maintenance expenses, timber is the material which must be used for superstructures. In small, permanent structures concrete, stone, and brick are excellent materials, preferably in the order named. The character of the structure should be governed by the material most readily obtained, though in some instances the available labor may be the determining factor.

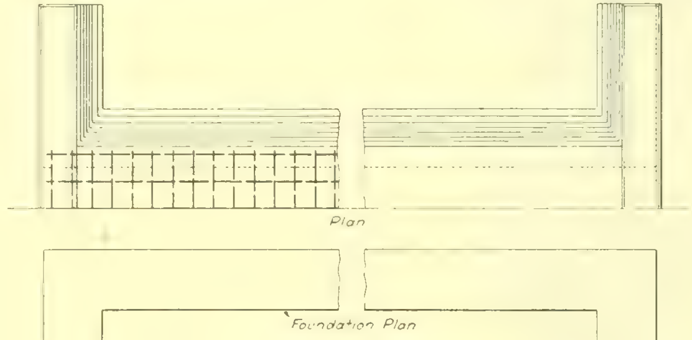

Bars A - Slope ¼ in per ft
12
T1
Span S
Height
Quantities computed to this line. Batter 4 in per ft
1'6"
Datum
T3
3
2 - 3'
Bars B
H
3" Weep Hole
Clear Width of Roadway
Not to exceed 1'-6"
3" weep Hole
Length of Culvert 'L'
1'-5"
1'-3 - 7
1' 3"
Quantities computed to this line. Batter 4 in per ft.
Plane
Width of base to equal 1ft. 3in. plus batter of 4in. per ft
M
Span S
Height
1'6"

Cross Section of Box

Longitudinal Section

Side Elevation

End Elevation



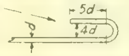
Plan

Foundation Plan

Design Data Weight of Paving or Ballast, 180 lbs per sq ft
Concentrated Load, 15-ton typical truck
Impact, 30 per cent of Live Load stresses.

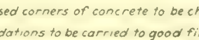
General Notes. Specifications, B.P.R. 1918.

Reinforcing bars shown are deformed bars. Plain bars may be used provided lengths given are increased by twenty diameters of the bars and both ends hooked thus



All stone work to be "Cement Rubble Masonry," either coursed or uncoursed. All concrete 1-2-4 mix.

Exposed corners of concrete to be chamfered thus



Foundations to be carried to good firm material with a minimum depth below bed of stream of 1 ft 6 in unless on solid rock.

Riprap and channel paving to be provided where necessary to prevent scour.

Railings designed to suit local conditions are to be placed on culverts where required.

Estimated quantities to be adjusted for length of culvert, footings below Datum Plane and for channel paving and riprap when used.

Complete permanent records shall be made of each structure as built, showing footing depths and any modifications of this plan.

Dimensions and Estimated Quantities above Datum Plane

Waterway			Dimensions							Quantities								
Span S	Height	Area of Opening	T1	T2	T3	H	M	Size and Spacing of Bars		Per Lineal Foot of Box			Two Curbs		2 End Walls	Total Quantities for Complete Culvert (L-22'6")		
								A	B	Concrete Slab	Steel	2 Rubble Side Walls	Total Concrete	Total Steel	Total Rubble	Concrete	Steel	Rubble
Feet		Sq Ft								Cu Yds	Lbs	Cu Yds	Cu Yds	Lbs.	Cu Yds	Cu Yds	Lbs.	Cu Yds.
2	1'-6"	3.0	6"	9"	1'-9"	4'-0"	11'-0"	½"-8"c to c 3'-3" long	½"-12"c to c for all spans	0.06	7.6	0.28	1.3	37	3.2	2.7	208	9.4
	2'-0"	4.0			2'-0"	4'-6"	12'-6"					0.36	1.5	42	4.5	2.9	213	12.5
3	2'-0"	6.0	6"	9"	2'-0"	4'-6"	13'-6"	½"-7"c to c 4'-3" long		0.08	10.5	0.36	1.6	45	4.5	3.4	281	12.5
	2'-6"	7.5			2'-3"	5'-0"	15'-0"					0.44	1.8	50	6.0	3.6	286	16.0
	3'-0"	9.0			2'-6"	5'-6"	16'-0"					0.54	1.9	55	7.8	3.7	291	20.0
4	2'-0"	8.0	6½"	10"	2'-0"	4'-6"	14'-6"	½"-6"c to c 5'-5" long		0.11	14.3	0.37	1.8	48	4.4	4.3	370	12.7
	2'-6"	10.0			2'-3"	5'-0"	16'-6"					0.46	1.9	54	5.9	4.4	376	16.2
	3'-0"	12.0			2'-6"	5'-6"	17'-6"					0.56	2.1	59	7.7	4.6	381	20.2
	4'-0"	16.0			2'-9"	6'-6"	20'-6"					0.73	2.4	69	12.5	4.9	391	28.9
5	2'-0"	10.0	7½"	10"	2'-0"	4'-6"	15'-6"	½"-6"c to c 6'-5" long		0.15	16.9	0.37	1.9	52	4.4	5.3	432	12.7
	2'-6"	12.5			2'-3"	5'-0"	17'-0"					0.46	2.0	57	5.9	5.4	437	16.2
	3'-0"	15.0			2'-6"	5'-6"	18'-6"					0.56	2.2	62	7.7	5.6	442	20.2
	4'-0"	20.0			2'-9"	6'-6"	21'-6"					0.73	2.5	72	12.5	5.9	452	28.9
	5'-0"	25.0			3'-3"	7'-6"	24'-6"					0.98	2.8	82	18.6	6.2	462	40.7

DESIGNED BY H. O. Pinton DATE July 11, 1918
DRAWN BY H. O. Pinton DATE July 15, 1918
TRACED BY James S. Clay DATE July 1918.
CHECKED BY J.S.C. DATE July 1918.

BUREAU OF PUBLIC ROADS
WASHINGTON, D.C.

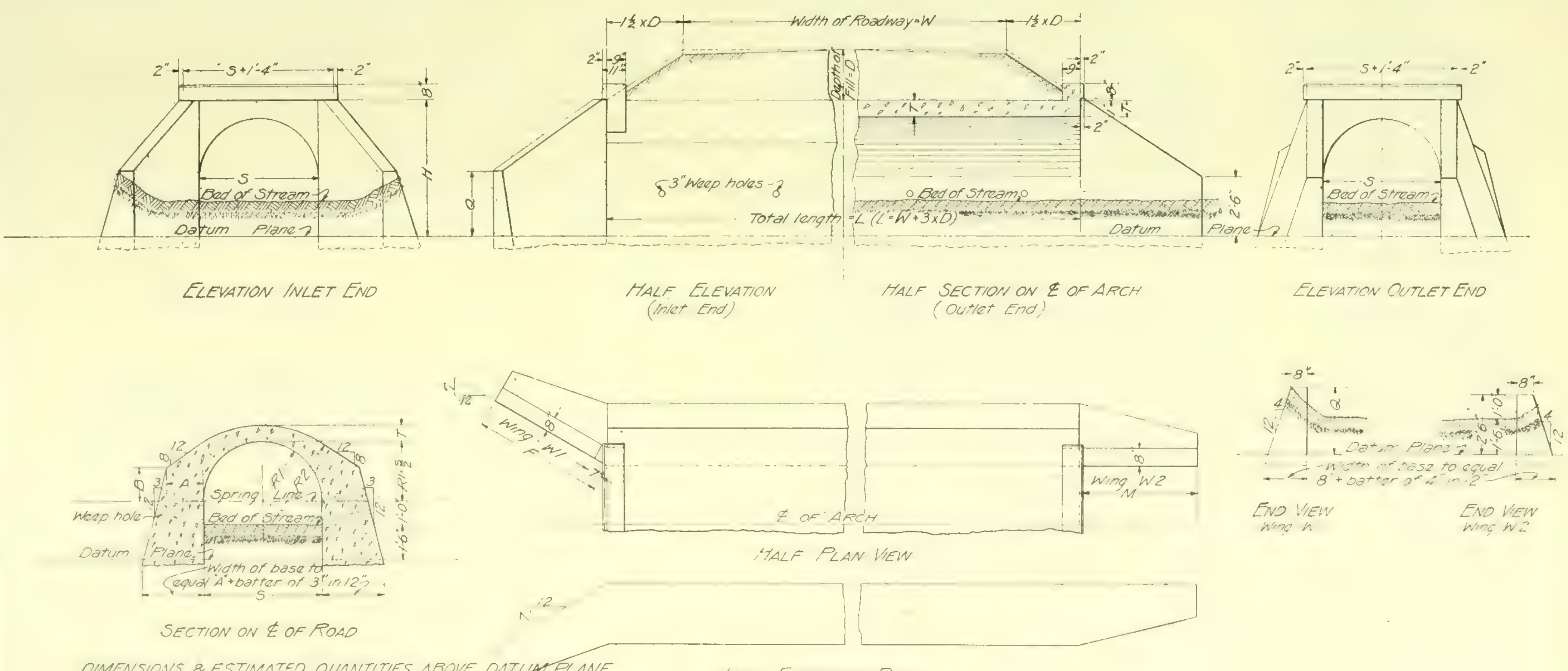
STONE CULVERTS

CONCRETE SLAB TOP
SPANS 2FT TO 5FT
JULY—1918

CORRECT: O. L. Grover
BRIDGE ENGINEER.

APPROVED:
CHIEF ENGINEER.

G-250



HALF FOUNDATION PLAN

DIMENSIONS & ESTIMATED QUANTITIES ABOVE DATUM PLANE

S Clear Span Ft	Area of Water Sq Ft	Dimensions: Arch R1	R2	T	A	B	Wings W1 F	Q	H	W2 M	Quantities above Datum Plane in Cu. Yds: Two wings W1	Two wings W2	Two spandrel walls	Arch per Lin Ft	Total for Culvert L = 30'-0
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	3.6	1'-0"	1'-6"	6"	8"	8"	2'-6"	3'-0"	4'-1"	2'-6"	0.7	0.8	0.2	.30	10.7
3	6.5	1'-6"	2'-3"	6"	1'-1"	9"	3'-3"	3'-0"	4'-7"	3'-3"	1.0	1.1	0.3	.46	16.2
4	10.3	2'-0"	3'-0"	7"	1'-5"	11"	4'-0"	3'-3"	5'-2"	[illegible]	1.5	1.6	0.4	.63	22.4
5	[illegible]	2'-6"	3'-9"	7½"	1'-10"	1'-0"	4'-9"	3'-3"	5'-8½"	5'-0"	2.0	2.2	0.5	.83	29.6
6	[illegible]	3'-0"	4'-6"	8"	2'-1½"	1'-2"	5'-6"	3'-6"	6'-3"	5'-9"	2.7	2.7	0.6	1.02	36.6
7	[illegible]	3'-6"	5'-3"	8½"	2'-4"	1'-5"	[illegible]	[illegible]	6'-9½"	[illegible]	3.4	3.6	[illegible]	1.23	44.6

Total quantities above Datum Plane for any length of culvert [illegible] plus quantities in columns 12, 13 and 14.

DESIGNED [illegible] DATE [illegible]
DRAWN [illegible] DATE [illegible]
TRACED [illegible] DATE [illegible]
CHECKED [illegible] DATE [illegible]

NOTE Specifications B.P.R. 1918

All concrete to be 1 : 2½ : 5

All corners to be chamfered thus: ¾

Foundations to be carried to good firm material, with a minimum depth below bed of stream of 1'-0 unless on solid rock.

Rip-rap and channel paving to be provided where necessary to prevent scour.

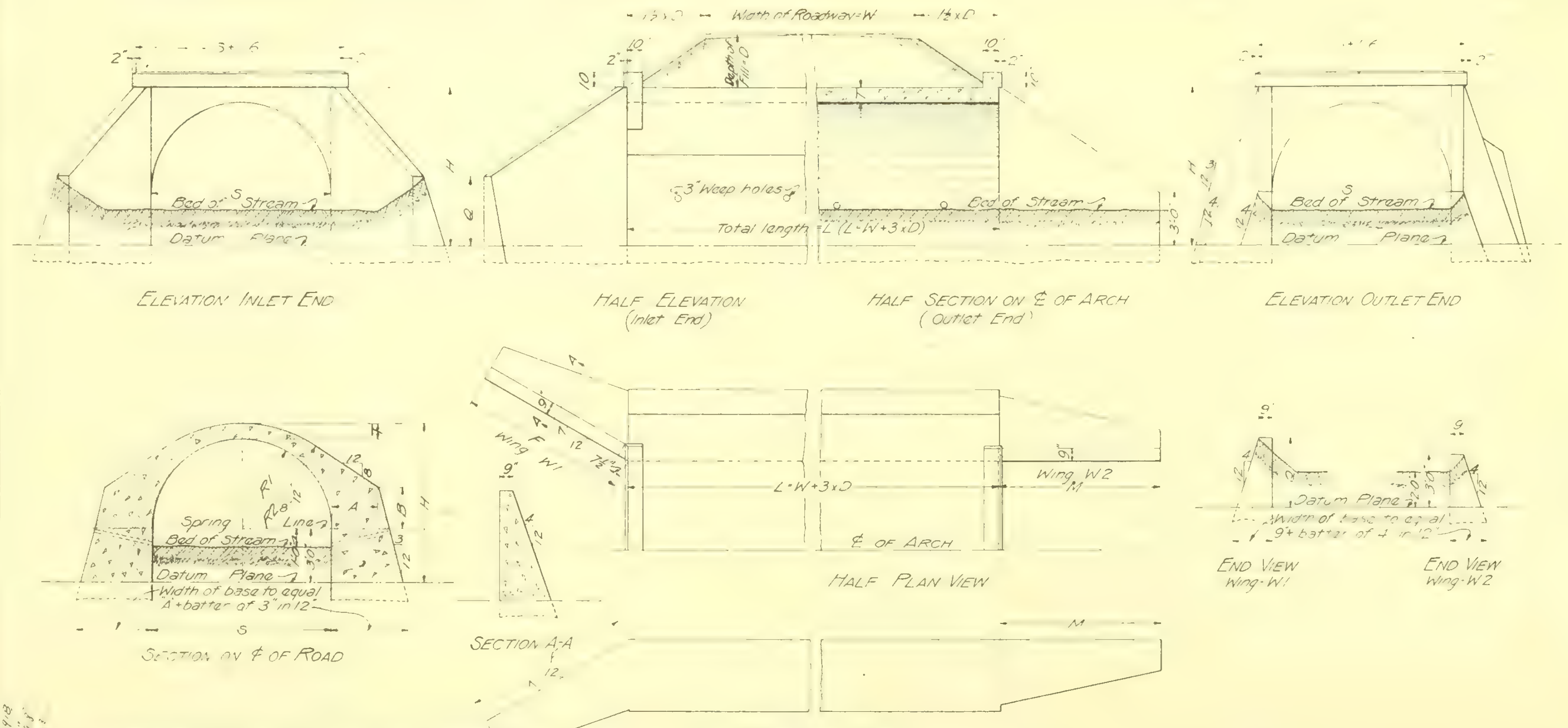
Estimated quantities to be adjusted for depth of culvert foundation below datum plane, and for paving and rip-rap if used.

Complete permanent records shall be made of each structure as built, showing footings, depths and any modifications of this plan.

ARCH CULVERTS
PLAIN CONCRETE
[illegible] 2 [illegible] FEET

BRIDGE ENGINEER
APPROVED
CHIEF ENGINEER

G-248



HALF FOUNDATION PLAN

DIMENSIONS & ESTIMATED QUANTITIES ABOVE DATUM PLANE

S Clear Span Ft	Area of Water Way Sq Ft	Dimensions									Quantities above Datum Plane in Cu Yds				Total for Culvert L=30'0"
		Arch					Wings								
							W1		H	W2					
		R1	R2	T	A	B	F	Q		M	Two wings W1	Two wings W2	Two spandrel walls	Arch per lin Ft	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8	33.1	4'0"	6'0"	9"	2'6"	1'7½"	6'9"	4'3"	7'9"	7'3"	4.8	5.0	1.0	1.54	57.0
9	40.8	4'6"	6'9"	9½"	2'7"	1'11"	7'6"	4'4"	8'4½"	8'1"	5.9	6.1	1.2	1.73	65.1
10	49.3	5'0"	7'6"	10"	2'8½"	2'2½"	8'3"	4'5"	8'10"	8'11"	7.0	7.2	1.3	1.96	74.3
12	68.6	6'0"	9'0"	11"	2'9½"	2'10½"	9'9"	4'8"	9'11"	10'6"	9.7	9.8	1.6	2.38	92.5
14	91.0	7'0"	10'6"	12"	2'11½"	3'6"	11'3"	4'10"	11'0"	12'2"	12.9	13.0	1.9	2.90	114.8

Total quantities above Datum Plane for any length of culvert equals L x quantity in column N° 5 plus quantities in column N° 12, 13 and 14

DESIGNED H O Linton DATE June 1918
DRAWN " DATE "
TRACED F. F. Falconer DATE July 9 18
CHECKED [illegible] DATE [illegible]

NOTE. Specifications B.P.R 1918.
All concrete to be 1:2½:5

All corners to be chamfered thus – ¾"

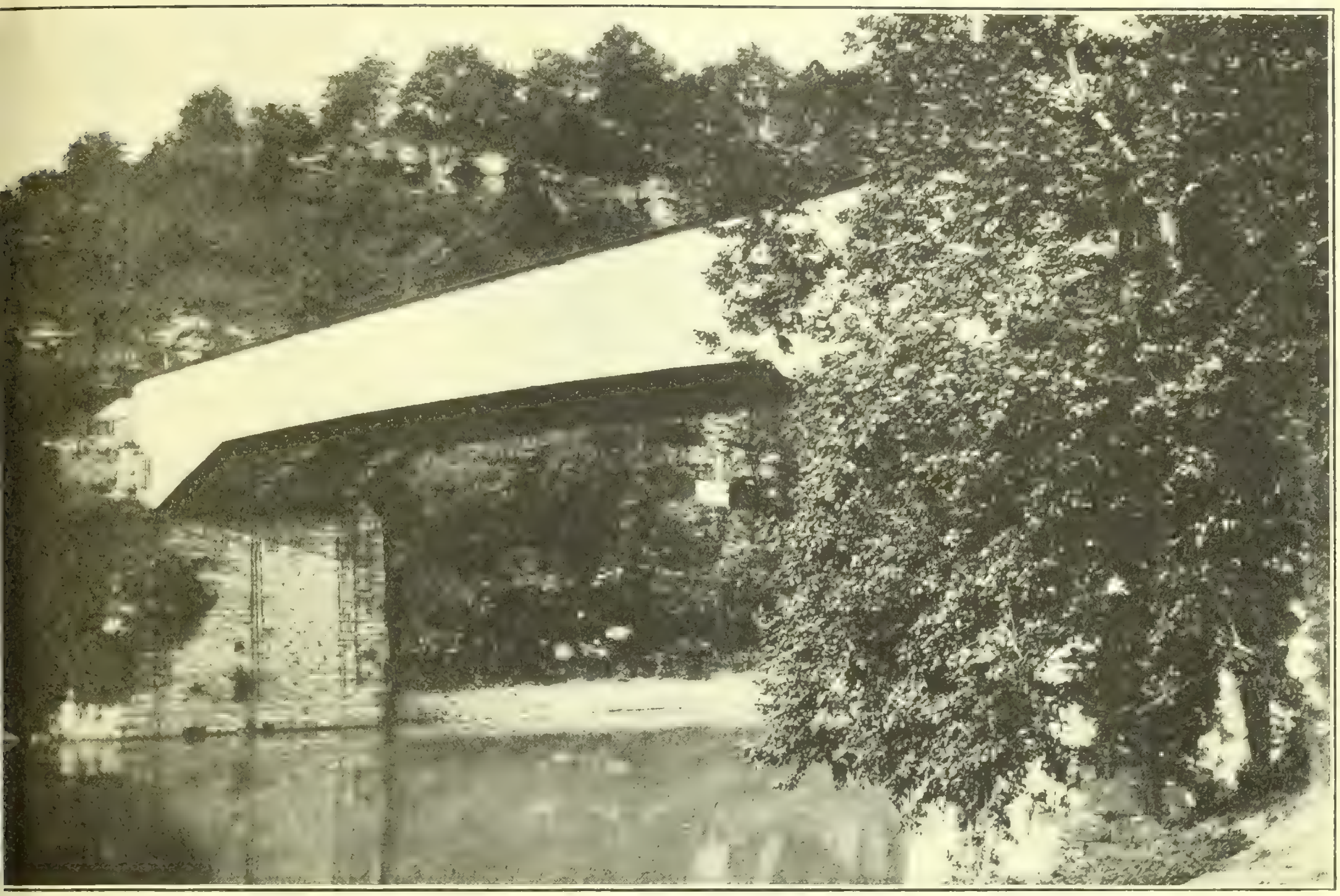
Foundations to be carried to good firm material, with a minimum depth below bed of stream of 2'-0" unless on solid rock

Rip-rap and channel paving to be provided where necessary to prevent scour

Estimated quantities to be adjusted for length of culvert, foundation below datum plane, and for paving and rip-rap if used

Complete permanent records shall be made of each structure as built, showing footing depths and any modifications of this plan

BUREAU OF PUBLIC ROADS
WASHINGTON, D.C.
ARCH CULVERTS
PLAIN CONCRETE
SPANS 8 TO 14 FEET
JULY 1918
CORRECT [illegible] BRIDGE ENGINEER
APPROVED T. H. MacDonald CHIEF ENGINEER
G-249



OLD WOODEN BRIDGE ACROSS THE KENTUCKY RIVER IN JESSAMINE COUNTY, KY., BUILT OF HEWN TIMBER IN 1838.

With a view to help in solving the bridge problems which present themselves under the existing conditions there have been prepared designs for small work where concrete, stone, and brick can be used, and which will produce permanent structures, and for timber construction where long bridges are necessary. The plans have been made to meet the usual conditions found in any section of the country.

CULVERTS OF RUBBLE MASONRY.

Small structures, built even under the present war conditions, should be constructed with a view to permanence. Culverts with small spans can be built readily without the use of steel, and of the most substantial construction.

In locations where suitable stone can be procured culverts of rubble masonry with stone covers may be constructed where the spans do not exceed 4 feet. Such culverts will prove satisfactory and will last for a long time. An example is one built in Brunswick County, Me. It is solid, of fine appearance, and gives perfect satisfaction. The construction is simple, and where suitable stone is found in the neighborhood within easy hauling distance the cost should be reasonable. In the selection of the stone the most durable should be used.

The following table gives the thickness and width of cover stones for culverts of 2, 3, and 4 foot spans:

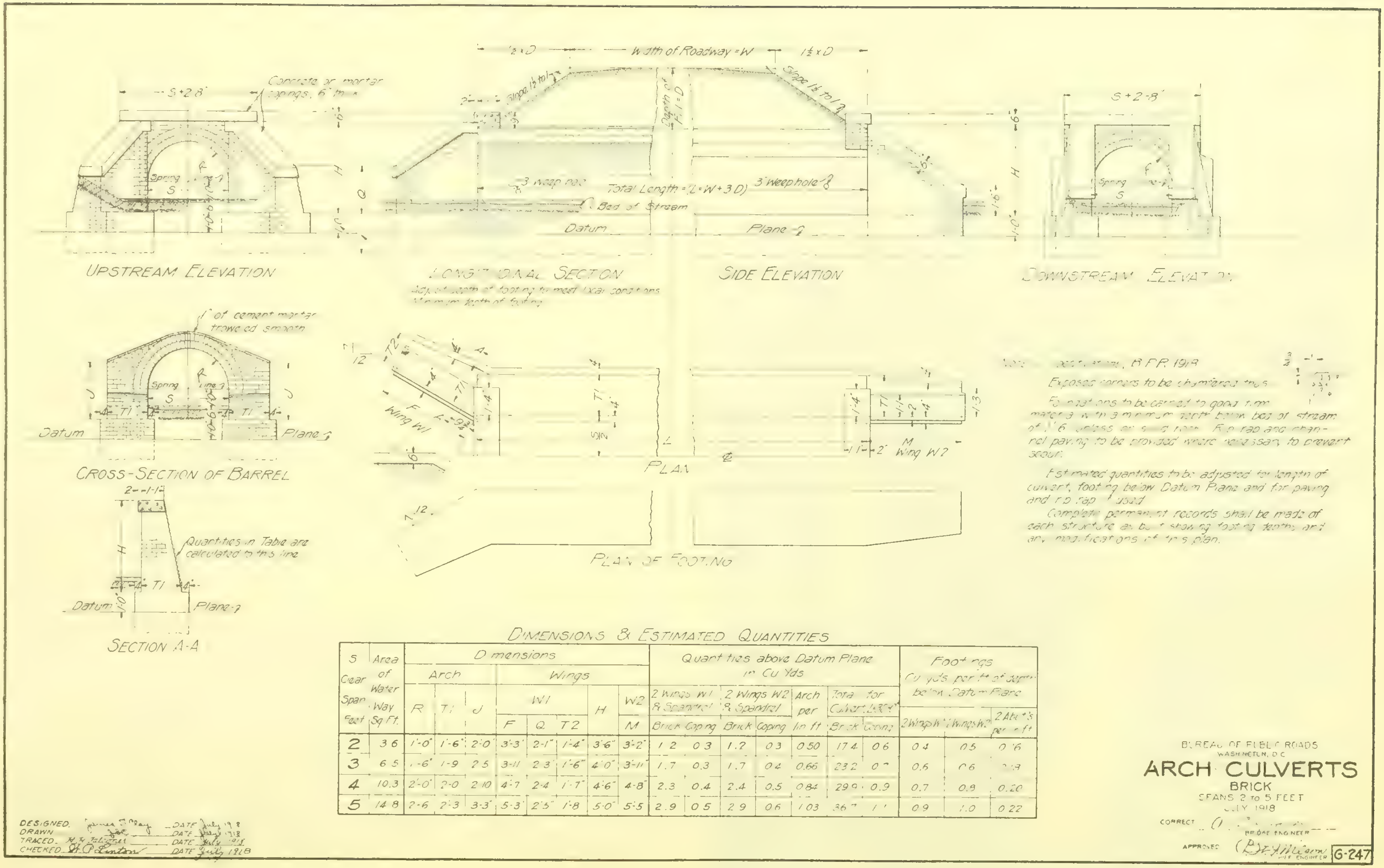
Dimensions of cover stones.

Span in feet.	Thickness in inches.	Width in inches.	Length in feet.
2	10	20	4
3	12	24	5
4	15	30	6

The masonry walls should be laid in cement mortar, and the stone slabs composing the cover should be laid in mortar beds and the cracks between stones filled with mortar.

Rubble stone suitable for masonry is found in many localities, where there are no stones suitable for the cover. Where this is the case the top may be made of reinforced concrete. This will require a small amount of steel reinforcement, but will permit the use of a longer span than is safe with the flat stone top. The construction of a culvert of this type of spans from 2 to 5 feet is shown herewith. This design and the specifications are made for a weight of paving or ballast of 180 pounds per square foot and to sustain a 15-ton truck load. Where a culvert of longer span is required permanent substructure can be built and the superstructure made temporarily with timber.

While suitable stone for the rubble masonry is to be found in many sections throughout the country there are many places where it can not be obtained.



DIMENSIONS & ESTIMATED QUANTITIES

S Clear Span Feet	Area of Water Way Sq Ft.	Dimensions: Arch R	Arch T1	Arch J	Wings W1 F	W1 Q	W1 T2	H	W2 M	Quantities above Datum Plane in Cu Yds: 2 Wings W1 & Spandrel Brick	2 Wings W1 & Spandrel Coping	2 Wings W2 & Spandrel Brick	2 Wings W2 & Spandrel Coping	Arch per lin ft	Total for Culvert L=30' Brick	Total for Culvert L=30' Coping	Footings Cu yds per ft of depth below Datum Plane: 2 Wings W1	2 Wings W2	2 Abut's per lin ft
2	3.6	1'-0"	1'-6"	2'-0"	3'-3"	2'-1"	1'-4"	3'-6"	3'-2"	1.2	0.3	1.2	0.3	0.50	17.4	0.6	0.4	0.5	0.16
3	6.5	1'-6"	1'-9	2'-5	3'-11	2'-3"	1'-6"	4'-0"	3'-11"	1.7	0.3	1.7	0.4	0.66	23.2	0.7	0.6	0.6	0.18
4	10.3	2'-0"	2'-0	2'-10	4'-7	2'-4	1'-7"	4'-6"	4'-8"	2.3	0.4	2.4	0.5	0.84	29.9	0.9	0.7	0.9	0.20
5	14.8	2'-6	2'-3	3'-3"	5'-3"	2'-5"	1'-8	5'-0"	5'-5	2.9	0.5	2.9	0.6	1.03	36.7	1.1	0.9	1.0	0.22

Note: [illegible] specifications, B.P.R. 1918

Exposed corners to be chamfered thus

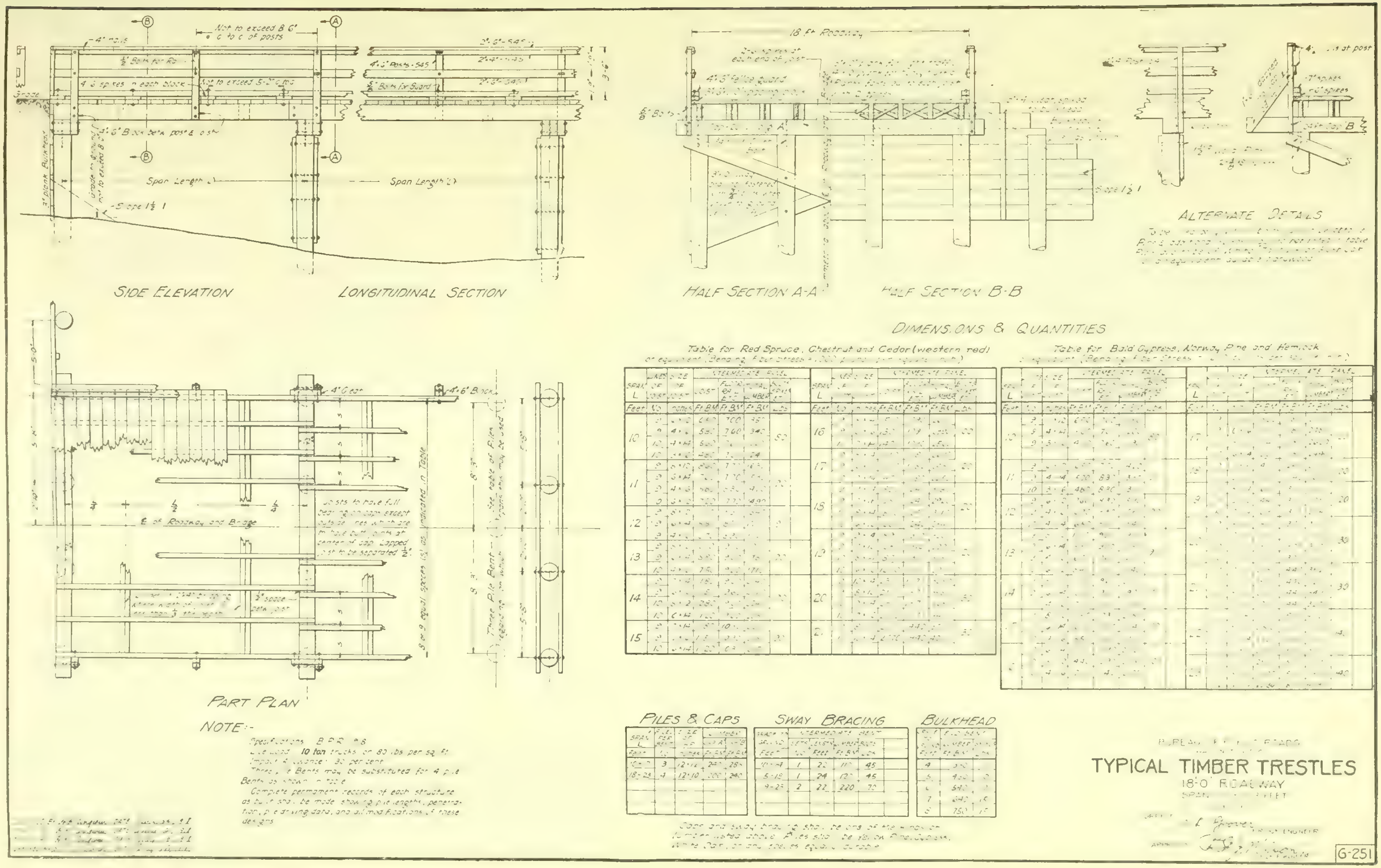
Foundations to be carried to good firm material with a minimum depth below bed of stream of 1'-6" unless on solid rock. Rip rap and channel paving to be provided where necessary to prevent scour.

Estimated quantities to be adjusted for length of culvert, footing below Datum Plane and for paving and rip rap if used.

Complete permanent records shall be made of each structure as built showing footing depths and any modifications of this plan.

DESIGNED James T. May DATE July 1918
DRAWN Joe DATE July 1918
TRACED H. W. [illegible] DATE July 1918
CHECKED H. P. Linton DATE July 1918

BUREAU OF PUBLIC ROADS
WASHINGTON, D.C.
ARCH CULVERTS
BRICK
SPANS 2 TO 5 FEET
JULY 1918
CORRECT [illegible]
BRIDGE ENGINEER
APPROVED B. H. Williams
CHIEF ENGINEER
G-247



DIMENSIONS & QUANTITIES

Table for Red Spruce, Chestnut and Cedar (western red)

Table for Bald Cypress, Norway Pine and Hemlock

PILES & CAPS

SPAN L	PILES PER BENT	SIZE OF CAP	LUMBER CAP A	LUMBER CAP B
Feet	No	Inches	Ft B.M.	Ft B.M.
10-17	3	12×12	240	28[illegible]
18-23	4	12×10	200	240

SWAY BRACING

HEIGHT ABOVE GROUND	INTERMEDIATE BENT SETS	LENGTH	LUMBER	RODS
Feet	No	Feet	Ft B.M.	Lbs
10-14	1	22	110	45
5-19	1	24	120	45
9-25	2	22	220	70

BULKHEAD

[illegible]	END BENT LUMBER	[illegible]
Feet	Ft B.M.	Lbs
4	[illegible]	[illegible]
5	400	[illegible]
6	540	[illegible]
7	640	15
8	750	15

Caps and sway bracing shall be one of the kinds of lumber listed above. Piles shall be yellow Pine, Cypress, White Oak, or any species equally durable.

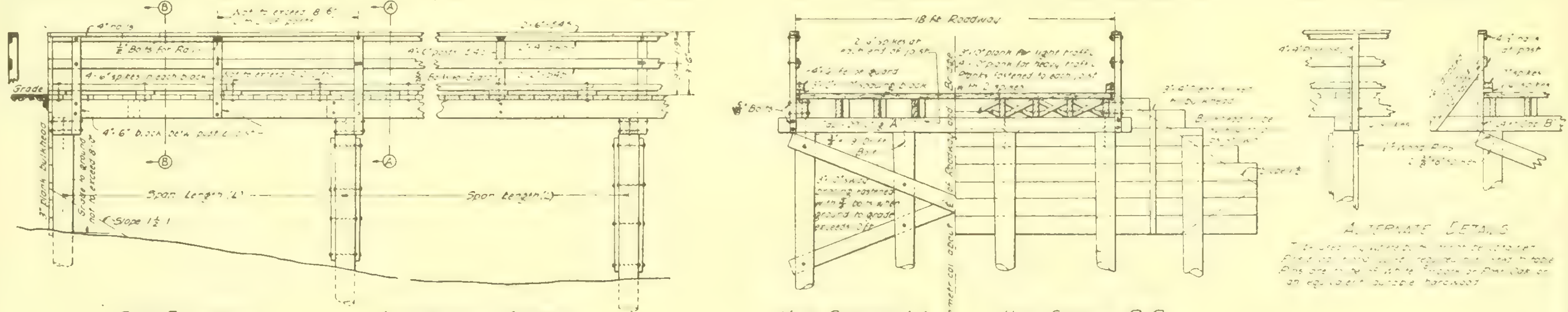
NOTE:-

Specifications B.P.R. #8
Live load 10 ton trucks or 80 lbs per sq ft
Impact allowance 30 per cent
Three pile Bents may be substituted for 4 pile Bents as shown in table
Complete permanent records of each structure as built shall be made showing pile lengths, penetration, pile driving data, and all modifications of these designs

BUREAU OF PUBLIC ROADS

TYPICAL TIMBER TRESTLES
18'-0" ROADWAY
SPAN [illegible] FEET

G-251

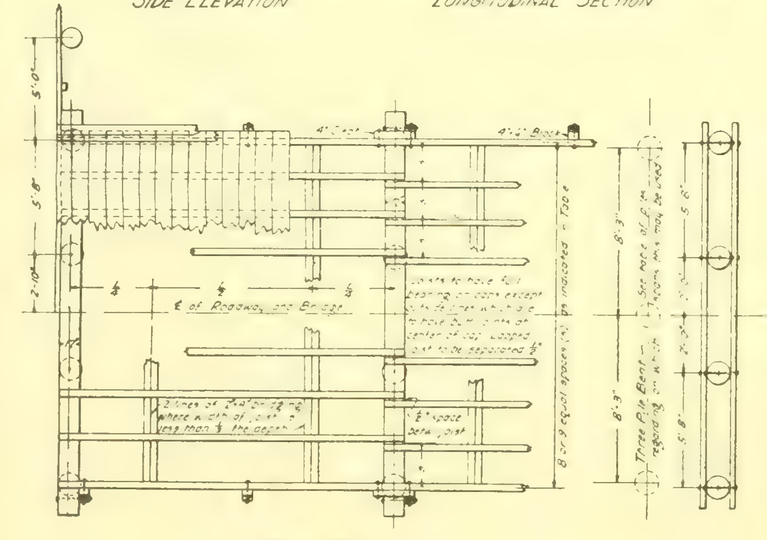


SIDE ELEVATION

LONGITUDINAL SECTION

HALF SECTION A-A

HALF SECTION B-B



PART PLAN

NOTE -

Specifications B P R 1918
Live Load 10 ton trucks or 80 lbs per sq ft
Impact Allowance 30 per cent
Three pile Bents may be substituted for 4 pile Bents as shown in table
Complete permanent records of each structure as built shall be made, showing pile lengths, penetration, pile driving data and all modifications of these designs

DIMENSIONS & QUANTITIES

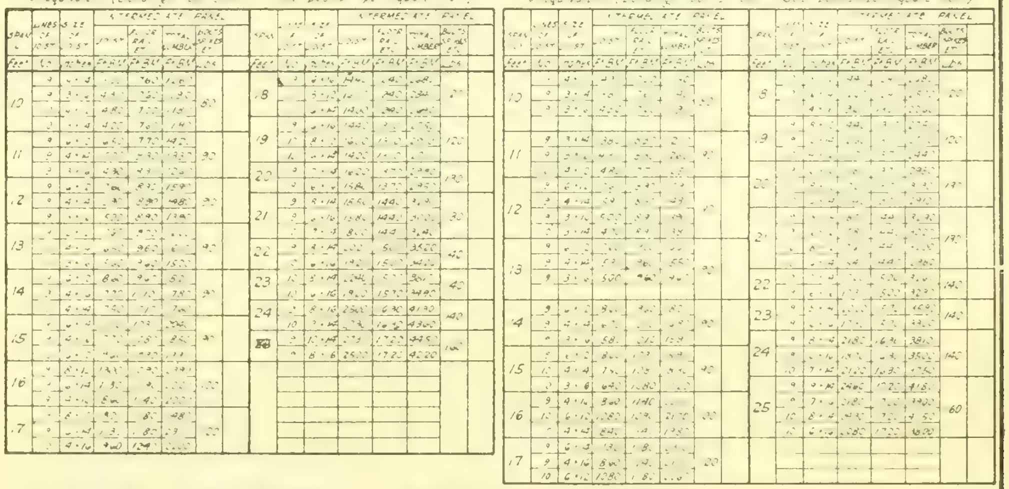


Table for Pacific Post Oak Western Larch and Tamarack

Table for Longleaf Pine White Oak and Douglas Fir (Pacific Coast)

PILES & CAPS

SPAN (L)	PILES PER BENT	SIZE OF CAP	LUMBER CAP A	LUMBER CAP B
Feet	No	Inches	Ft BM	Ft BM
10-17	3	12×10	200	240
18-25	4	12×10	200	240

SWAY BRACING

GRADE TO GROUND	INTERMEDIATE BENT SETS	INTERMEDIATE BENT LENGTH	INTERMEDIATE BENT LUMBER	INTERMEDIATE BENT BOLTS
Feet	No	Feet	Ft BM	Lbs
10-14	1	22	110	45
15-18	1	24	120	45
19-23	2	22	220	70
24-26	2	24	240	70

BULKHEAD

GRADE TO GROUND	END BENT LUMBER	END BENT SPIKES
Feet	Ft BM	Lbs
4	330	10
5	432	10
6	540	10
7	640	15
8	750	15

Caps and sway bracing shall be one of the kinds of lumber listed above. Piles shall be Yellow Pine, Cypress, White Oak, or any species equally durable.

DESIGNED BY [illegible] DATE June 29 1918
DRAWN BY [illegible] DATE July [illegible] 1918
TRACED BY [illegible] DATE July 18 1918
CHECKED BY [illegible] DATE July [illegible] 1918

BUREAU OF PUBLIC ROADS
WASHINGTON D.C.

TYPICAL TIMBER TRESTLES

18'-0" ROADWAY
SPANS 10 TO 25 FEET
JULY 1918

CORRECT O. L. Grover. BRIDGE ENGINEER
APPROVED [illegible] CHIEF ENGINEER

G-252

In some localities it may be desirable to substitute plain mass concrete in place of the rubble masonry, because of the difficulty in obtaining suitable stone.

THE CONSTRUCTION OF ARCHES.

Where it is necessary to make longer spans the arch is the only type of permanent structure that can be built without metal. The height needed and foundation conditions are the controlling features in this construction. The arch span will not prove substantial without a good solid foundation, either of cemented gravel, hardpan, or rock. So important is this in securing permanency that the arch should not be selected until after the most thorough examination of the location. In some streams the bed is of such a character that there will be no great difficulty in securing the proper foundation. In others all sorts of conditions may exist and make it difficult to provide one.

Where it is possible, the foundation should be on solid rock. Where this is not possible, it is often practicable to secure adequate foundations by carrying the footings deeper, by driving piles or sometimes by spreading the footing over a wider area. In all cases where solid rock is not found the problem should be submitted to an engineer for solution.

The three materials most used in arch construction are concrete, stone, and brick, preferable in the order named.

It is necessary to carry the foundations well below the bed of the stream. For the smaller spans this should not be less than 1 foot 6 inches and for the longer ones not less than 2 feet, unless they are laid on a bed of solid rock. Riprap and channel paving should be provided where it is necessary to prevent scour.

In building arches of stone or brick, the top of all masonry should be protected by copings of concrete or by copings of large, selected stone with grouted joints.

A road of any length usually will require many small culverts. Those built in accordance with the designs shown will prove satisfactory and durable. They are suitable for construction under present war conditions and will serve all requirements.

In the South, where the climate is not subject to hard freezing, common hard burned brick may be used in building arches, but should not be used where good rubble stone is to be had. In the colder sections of the country brick does not give as good results, because it absorbs moisture and disintegrates by freezing.

The foundations should be carried to good firm material, and have a minimum depth below the bed of the stream of 1½ feet unless on solid rock. The brick should be laid in cement mortar and be covered with 1 inch of cement mortar troweled smooth.

TIMBER TRESTLES AND BRIDGES.

Timber may be used with satisfactory results for both temporary and permanent structures, and to good advantage where brick, stone, and concrete are not easily secured. There is hardly any part of the country where good timber can not be obtained, and for spanning streams of considerable size the timber trestle or bridge is the usual type of construction under emergency conditions. It is often hard to draw the line as to just what is meant by temporary and permanent structures. Roads and bridge building is determined by the expected use, the necessity of early completion, probably most often by the available funds. At present the labor available must also be a controlling factor. Bridges will be built to last as long as they will perform the required service, though it may be expected to replace them with better and more permanent structures when additional funds are at hand or conditions warrant.

Timber deteriorates unless protected or treated for preservation, and for that reason is recommended only for temporary structures and where other materials are not available. The ordinary life of a timber trestle or bridge can be practically doubled by a good preservative treatment, and if the structure is expected to remain in use beyond the natural life of the wood it may be advisable, in order to keep down heavy maintenance expenses, to use a preservative treatment.

Bridges may be built of timber to serve any purpose required and will last many years. They can not be so economically maintained as bridges of reinforced concrete, but so long as it is not practical to make use of reinforced concrete the timber structure will be the one to build, but it must be borne in mind that it should rest on permanent foundations.

TIMBER BRIDGES STANDING 80 YEARS.

That the timber structure will prove durable when properly protected there is no doubt. A large number of wooden bridges are found in the Eastern and Southern States that have been in use from 40 to 60 years and are still in a good state of preservation. One example is the wooden bridge, with a span 280 feet long, over the North River, at Bridgewater, Va., which was built in 1866. The timbers are mostly hewn pine. Another bridge is in Jassamine County, Ky., over the Kentucky River, built in 1838. It also is of hewn timber, cut in the mountains and floated down the river to the site.

In timber construction the most durable timber should be used that can be obtained locally. The general type of temporary construction is the trestle. Designs have been prepared for typical trestles, which are shown herewith. Tables are given, made up for extreme fiber stresses of 1,000, 1,200, 1,400, and 1,600 pounds per square inch, in order to provide for the use of the better species of timber to be obtained in the various parts of the country. These designs are based on concentrated loads of 10-ton trucks passing.

The more available timbers with a fiber stress of 1,600 pounds per square inch include long-leaf pine, white oak, and Douglas fir. In the 1,400-pound class is included Pacific post oak, Western larch and tamarack, in the 1,200-pound class bald cypress, Norway pine, and hemlock, and with a fiber stress of 1,000 pounds per square inch red spruce, chestnut, and red cedar. The tables are made up to include spans of from 10 to 25 feet. Piles used should be yellow pine, cypress, white oak, or some equally durable species.

CONSTRUCTION UNDER PRESENT CONDITIONS.

In meeting the present-day conditions limiting the construction of bridges local supplies of material and labor will be the determining factors. In general, the decision as to construction should be as follows:

Keep large structures in service by repair, whenever it is possible.

Put temporary spans on permanent substructures.

Put in temporary trestles where it can be done.

Small structures should be made permanent.

Where large structures are destroyed and must be replaced to keep the road open or where emergency use requires the building of a new crossing make temporary pile trestle structures if the nature of the stream does not make this type impracticable. Where temporary structures are not advisable timber structures may be protected so as to be more or less permanent.

DIRECT LOADING A SUCCESS IN CONCRETE CONSTRUCTION

By Charles M. Upham, Chief Engineer, Delaware State Highway Department.

WITH the present high costs of labor and materials it becomes increasingly necessary that labor saving devices and methods be used wherever possible in all construction. A few details generally are worked out on any particular piece of work, but probably no cost reducing method has been worked out any more thoroughly and successfully than direct loading on the recent construction of a 10-mile section of the Coleman Du Pont road in Sussex County, Del.

The line of the Du Pont Road is practically straight, there being only three curves in the 10-mile section. New location was followed with the exception of approximately two miles. The policy of locating the road just outside of the small towns, which was done in this case, seems to be gaining in favor with the people of the adjacent territory, for the road is available for use, and the small towns are not in any way troubled or subjected to the hazards of through auto traffic. The through auto traffic, on the other hand, is not obliged to slow down nor does it encounter the many cross streets that it would in passing through the villages or towns.

DRAINAGE PRACTICALLY PERFECT.

The grades on this section of the Du Pont Road are very light, in no case exceeding 3 per cent. On account of this flat nature of the country and of the numerous ditches, a complete drainage survey was made necessary and in some instances it was necessary to dig ditches nearly a mile distant from the road to carry off the water. This drainage survey assured that the drainage on this section of road was practically perfect, and now no water can be seen alongside the road even after a heavy rain.

Grading was carried on as for any road, but considerable stress was laid on the necessity of securing uniform compaction of the subgrade.

The construction was standard concrete, with special care exercised as to the quality and cleanliness of the materials, considerable stress being laid on the inspection of construction.

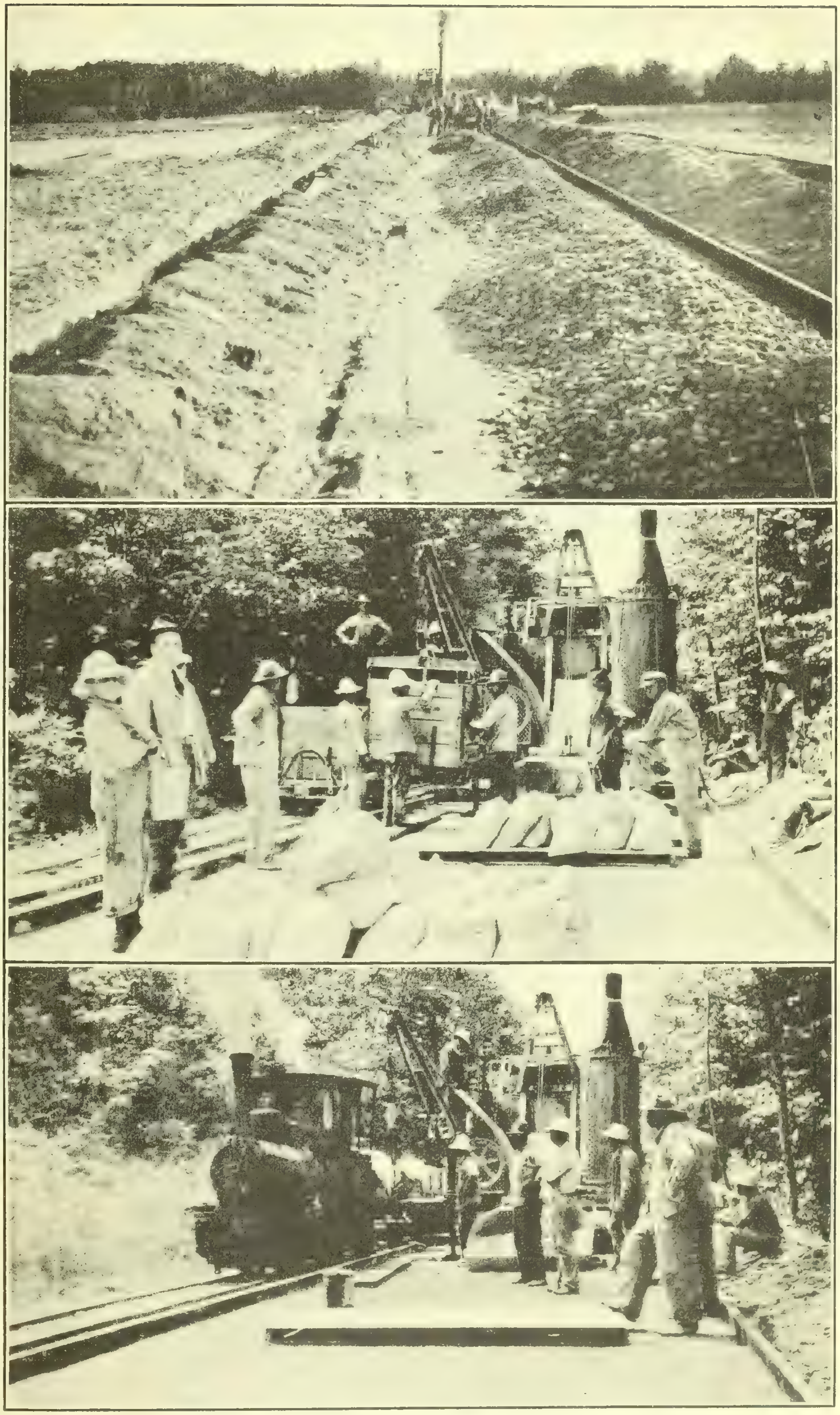
The roadway is 14 feet wide, 7 inches deep in the center, and 5 inches on the sides. The concrete was mixed in the proportions of 1 part cement to 2 parts of fine aggregate and 4 parts of coarse aggregate.

The only ingredients obtained locally for the construction of the road was water, which was obtained from wells driven about a mile apart alongside the road and was connected with 2-inch pipe lines with taps at intervals of approximately 150 feet. In some instances a small elevated storage tank was used, but where there was a sufficient supply of water this was not necessary.

CONTRAST WITH OLD METHOD.

On account of the lack of suitable materials in the nearby vicinity, it was necessary that all materials be delivered by railroad.

The new feature on this particular construction was the direct loading and method of handling the materials in marked contrast to the old procedure

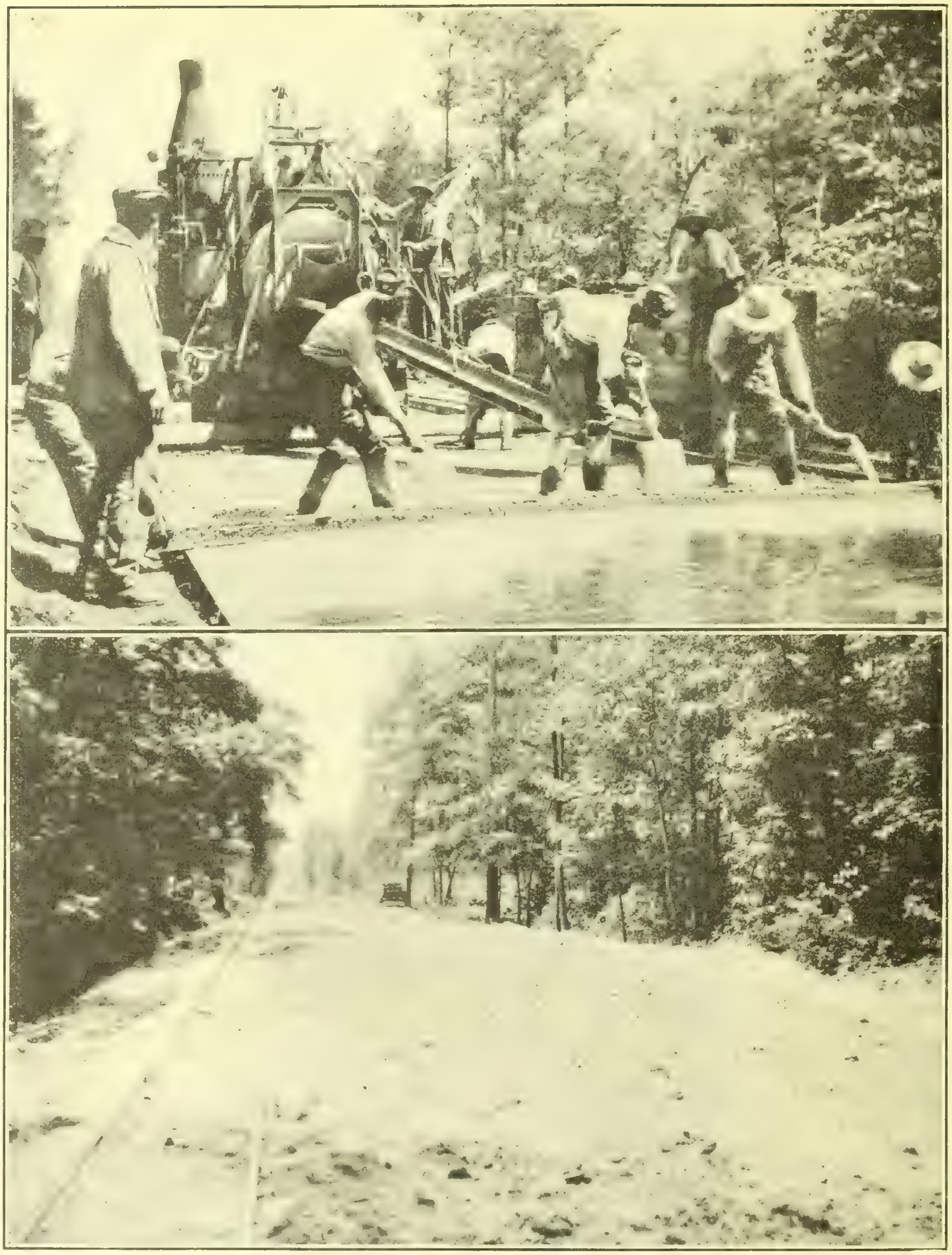


THE OLD METHOD AND THE NEW. DUMPING MATERIAL ON THE GRADE AND HANDLING BY DIRECT LOADING WITHOUT LOSS AND AT A SAVING IN TIME AND LABOR.

of storing the fine and coarse aggregates on the subgrade in front of the mixer and loading the mixer by means of wheelbarrows dumped into the skip. Many times under this old method it happened that the materials were not distributed uniformly on the subgrade, and quite often the wheelers had to push their wheelbarrows considerable distance, while at other times there would be too much material on the subgrade, making it necessary to remove enough to allow room for the wheelers to work.

Careful records kept of this method show that at least in one instance there was a loss of 10 per cent of the fine aggregate and of 8 per cent of the coarse aggregate.

With the material dumped on the subgrade there is always a chance that dirt will be picked up from the subgrade when the material is shoveled into the wheelbarrows. When the direct loading is used, this hazard of getting dirt from the subgrade mixed into the aggregates, as well as any loss of aggregate, is overcome entirely. Not only was the material kept clean and a great saving made in eliminating the loss of aggregate materials, but one complete handling of the materials was eliminated and approximately 12 men were released from the mixer gang.



TOP—SHOWING CONCRETE WITH A STEEL TEMPLATE. BELOW—SHOWING EARTH BLANKET WHICH IS KEPT ON FOR THIRTY DAYS.

USE INDUSTRIAL RAILWAY.

Briefly, the direct loading method is described by stating that the materials to be used in the construction of the road are loaded directly from freight cars into box containers, in correct proportions, transported to the concrete mixer and dumped directly into the skip. For emergencies, stock piles of sand and stone were maintained at the freight station, but these were seldom used.

In this particular instance the containers which held sufficient aggregate for a three bag batch were transported to the construction by means of an industrial railway, but there seems to be no reason why this same method could not be carried on by use of motor trucks. Two containers were placed on each car and a train load of 15 cars hauled to the mixer. Containers were lifted from the cars by means of a derrick attached to the concrete mixer. Three men were required to dump the container into the skip and one man was necessary on the derrick to lift the containers from the truck. After the container was lifted approximately 4 inches it would clear the body of the car.

The transporting of materials was carried on by three trains handled by an industrial engineer. While one train was being loaded at the freight station, the second train was being hauled to the concrete mixer, and the third train was being unloaded at the concrete mixer. This method worked out very satisfactorily up to a 4-mile maximum haul, and with proper equipment there should be no limit for the satisfactory working of this method. The cars holding the containers are moved at the concrete mixer by hand or by mule.

COMPLETE 600 FEET IN DAY.

It was necessary to have a siding for storing the empty cars near the mixer in order to allow the trains to pass. This siding was moved each day with very little trouble and at small expense.

The specifications required that all concrete should be mixed one and one-half minutes and there was no delay on account of the direct-loading method. Under favorable conditions, approximately 600 feet of 14-foot pavement was completed in one day, all the concrete having been mixed one and one-half minutes.

The completion of the concrete road was practically standard practice. After the subgrade was brought to the proper elevation and uniformly compacted it was thoroughly wet before the concrete was placed. The concrete was shaped with a steel template, approximately 8 inches wide, which left the surface comparatively smooth. After a short time the surface was finished with a belt, and the small places that were not smooth after the belt was used, were troweled. It is expected to try the roller method on the next section. Immediately after finishing, sun covers were placed over the concrete to protect it from the sun and wind. These covers, constructed of wood frames covered with canvas or heavy cloth, were supported about 6 inches above the pavement. Experiments show that they are a great help in curing the concrete and preventing the small cracks due to quick drying of the surface.

ROAD COVERED 30 DAYS.

As soon as the concrete was sufficiently hard, an earth covering, practically 2 inches deep, was thrown on the roadway and thoroughly wet, in which condition it was kept for approximately 14 days. The earth covering was not cleared off for 30 days. This time of curing was possible, because the greater part of the road was located through new territory and very little traffic was encountered. After 30 days the roadway was cleared and the road thrown open to traffic.

Not only has the direct loading produced more uniform and better concrete, but it has increased the output of a plant and at the same time reduced the cost of construction.

NATURE MIXED SAND-CLAY FOR ALABAMA FEDERAL AID ROADS

By **J. T. BULLEN**, District Engineer, Bureau of Public Roads.

IN its first completed Federal aid project Alabama has contributed an example of nature-mixed sand clay construction. This road, in Pike County, is in the peanut-growing country. Another similar road is nearing completion in Dale County. The material for the surfacing, dark red in color, was taken already mixed from deposits found near the work. Each project forms a part of the Ozark, Troy, and Montgomery road, the project in Pike County being 9 miles in length, and the one in Dale County about 8¾ miles.

The project agreement for Pike County was executed October 17, 1917, and work was begun with county convicts on October 26, 1917, and on July 10, 1918, the road was complete except the culvert headwalls. The project agreement estimate was for $20,662, or $2,268 per mile, and the amount of Federal aid requested was $10,331, and the final estimate will not vary materially from these figures.

The Dale County project agreement was executed October 17, 1917, and work was begun with county forces on December 20, 1917, and it is now about 85 per cent completed. The estimated cost of this road was $20,064, or $2,300 per mile; and Federal aid was requested in the amount of $10,032.

Excavation on both of these projects runs between 5,000 and 6,000 cubic yards per mile, and the natural sand-clay surfacing was spread 16 feet wide on the Dale County project, and from 24 to 30 feet wide on the Pike County project; and approximately 10 inches deep, loose, in both cases.

Little or no bridging was necessary on these projects, as the location of both follows ridge routes. Quite a number of double-strength vitrified culverts were necessary, however, and these were put in.

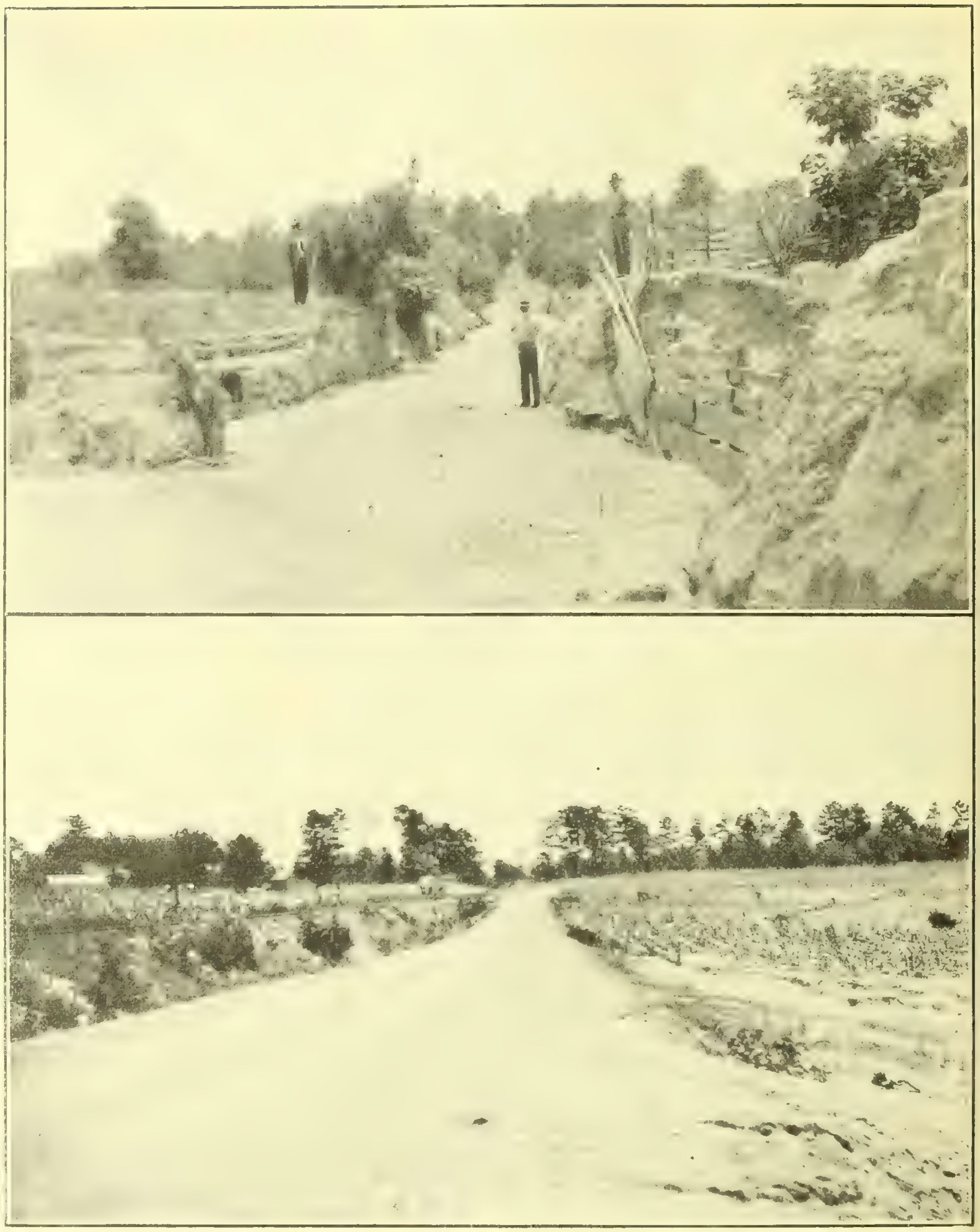
In the case of Dale County the width of the crown of the road is 24 feet and the surfacing of sand-clay 16 feet. On this work two out of four grade crossings were eliminated, and the road which was formerly of sand so deep that even walking was extremely difficult, has been converted to the conditions shown in the photographs.

The Pike County project also traversed a sandy character of soil and was for the most part deep sandy road before improving.

The people in these two counties are deeply interested in good roads and expect to give them the most careful maintenance. They have learned from past experience that the maintenance is just as necessary as was construction in the first instance.

As well as being the main highway between Troy, Ozark, and Montgomery, these projects form one of the main highways from Montgomery into the Florida Peninsula. It passes through a country that has recently developed what has proven to be two of the foremost crops in this section, namely, the velvet bean and the peanut. A number of mills have sprung up in this section for crushing the nut, and various by-products are also developed. This is also known as the wire-grass section of Alabama, and is a great cattle and hog raising country; in fact, on one day last winter in the small town of Ozark, having a population of about 3,000 people, $18,000 worth of hogs were sold by local farmers.

On account of the fact that the peanut and velvet bean are cash crops, and the prices have been so remunerative in the last year, the automobiles in use in the territory adjacent to this road have increased 100 per cent in number within a year.



THE OLD AND THE NEW. AT THE TOP TAKEN OPPOSITE THE POINT ILLUSTRATED BELOW IS SHOWN A LOOSE SAND ROAD IN DALE COUNTY, ALA., THE SAND BEING 10 INCHES DEEP AND THE ROAD LITTLE MORE THAN A CHANNEL FOR DRAINAGE. BELOW—THE NEW NATURE-MIXED SAND-CLAY HIGHWAY.

The particular quality of sand and clay used in surfacing has in the past proved very satisfactory for roads having a medium amount of traffic; and on account of the proximity of the surfacing material, the expense of keeping this road in repair, even under medium heavy traffic, is only nominal. The surfacing serves equally well during dry weather and wet seasons.

JUNE RECORD OF FEDERAL AID.

The month of June is distinguished by the unusually large amounts of money allowed for single projects, having 11 projects for which the sums to be spent by the States alone are in excess of $200,000 each. In all 135 projects were submitted to the Secretary of Agriculture for consideration, of which 89 were executed in final agreement. These projects covered 1,448.601 miles of road and the estimated expenditures to cover construction are $10,220,236.91 with Federal aid of $4,215,640.74.

ALABAMA'S FIRST COMPLETED FEDERAL AID PROJECT. NATURE-MIXED SAND-CLAY ROAD IN PIKE COUNTY. THE PEANUT CROP OF THIS COUNTY IN 1917 WAS WORTH $2,000,000.

Wisconsin had the largest number of projects, 17, with a mileage of 65.92, State expenditure $568,247.97, Federal aid allowed $189,420.33. Nebraska, however, leads in the amount of mileage, having submitted seven projects covering 257.78 miles of road for which the State expects to spend $469,395.91 and Federal aid to the extent of $234,697.94 is asked.

Nebraska also submitted the longest single project, covering a sand-clay road 83.65 miles long through Kearney, Adams, Clay, and Nuckolls Counties, for which the State will pay $138,683.09 and the Federal aid allotment is $69,341.54. Nebraska has the second longest project of 57.37 miles with Illinois running a close second with two projects of 55.30 and 54.50 miles respectively.

The most expensive single project is $904,700 for a stretch of 54.50 miles in Illinois of bituminous macadam and concrete construction for which Federal aid to the extent of $407,115 was allowed. Illinois also has the largest total expenditure of any State, having only two projects with a total estimated expenditure by the State of $1,385,040.92 while the Federal allowance is $620,349.02.

In the five projects submitted by Idaho covering 99.36 miles of construction, an expenditure of $701,577.04 is involved, with Federal aid allowance of $271,000. Ohio has a single project of brick road construction, 16.20 miles long, on which it expects to spend $761,117.50 and has asked $165,000 of Federal aid.

California is going to spend $210,668.48 of its money on an earth road, 15.94 miles long in Shasta County, and has been allotted $105,334.24 from Federal aid funds.

Washington has planned a bridge in Lewis County which it expects will cost $120,432.40 in addition to the allowance of $60,000 Federal aid. The shortest shortest single project is of bituminous macadam construction in Rhode Island, being 1.15 miles to cost $40,918.35 furnished by the State and $11,500 from Federal aid funds.

FEDERAL AID IN DETAIL FOR JUNE.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	15	Houston	4.3	Sand-clay		June 24	[1] $5,106.98	[1] $2,552.49
	18	Jefferson	6.0	Bituminous macadam		June 26	23,735.37	11,867.68
Arkansas	18	Benton	6.05	Gravel		June 7	13,537.98	6,768.99
California	7	Shasta	15.94	Earth		June 24	210,668.48	105,334.24
Colorado	3	Lake and Chaffee	8.94			June 27	62,614.42	31,307.21
	4	Garfield and Rio Blanco	21.00	Gravel or stone, and earth		June 29	78,831.43	39,415.71
	6	Prowers	3.13	Gravel and shale		June 27	23,838.36	11,919.18
Florida	4	De Soto	3.05	Brick or asphalt concrete	June 26		58,961.43	29,480.71
Georgia	3	Valdosta, Brooks, and Lowndes.	6.80	Sand-clay	June 4		56,045.22	28,022.61
	18	Dooly	11.40	do	June 29		32,561.92	10,000.00
	20	Carroll	15.20	Topsoil	do		47,181.20	20,000.00
	22	Milton	10.80	do	do		36,080.00	12,500.00
	25	Candler	13.60	Sand-clay	do		18,574.87	8,500.00
	30	Cobb	17.90	Topsoil	do		35,579.50	15,000.00
Idaho	3	Custer	20.00	Earth		June 29	71,327.42	23,000.00
	4	do	1.36	do		do	8,088.87	2,000.00
	5	Lemhi	38.00	do		do	298,937.99	135,000.00
	6	Idaho	22.00	Macadam and earth	June 7		243,988.80	86,000.00
	7	Custer	18.00	Earth		June 29	79,233.96	25,000.00
Illinois	2	Will, Kankakee, and Iroquois	54.50	Bituminous macadam and concrete.	June 5		904,700.00	407,115.00
	4	Cook and Lake	21.85	Concrete	June 10		481,340.92	213,234.02
Iowa	2	Woodbury	55.30	Earth		June 29	141,193.09	34,285.90
	3	Jefferson	20.53	do		do	65,719.72	16,830.55
	4	Delaware	14.65	Gravel		do	108,651.18	22,297.55
	5	Buchanan	15.52	do		do	83,785.41	22,141.35
	6	Ringgold	12.00	Earth		do	59,254.14	21,086.95
	7	Marion	18.00	do		do	77,465.90	22,531.85
Kansas	10	Geary	7.55	Concrete	June 10		152,702.06	22,905.31
Kentucky	1	Bond	8.11	Brick or concrete		June 24	214,193.31	76,944.89
	3	Rowan	8.085	Earth	June 27		48,400.00	24,200.00
	4	Carter	11.27	do		June 29	124,813.16	62,406.58
	6	Rockcastle	7.20	do	June 4		27,614.00	13,807.00
Louisiana	10	Richland	7.77	Gravel		June 4	90,612.62	41,743.00
Massachusetts	6	Barnstable	1.818	Bituminous concrete		June 25	21,356.04	10,678.02
Michigan	9	Washtenaw	2.89	Concrete or brick	June 3		90,838.00	28,900.00
	17	Chippewa and Mackinac	8.00	Gravel		June 22	68,921.39	34,210.69
	21	Kalamazoo	6.00	Concrete		June 24	127,509.36	60,000.00
	23	Berrien	3.43	Macadam	June 10		42,650.19	21,325.09
Minnesota	4	Crow Wing	20.57	Gravel		June 29	74,476.47	30,000.00
	5	Freeborn	15.41	do		June 17	57,987.62	23,100.00
	8	Winona	6.25	Earth	June 23		24,000.00	12,000.00
	18	Wabasha	7.72	do		June 17	39,557.88	15,000.00
	33	Murray	29.10	Gravel	June 10		74,775.36	25,000.00
Mississippi	1	Itawamba	23.65	do		June 25	129,458.84	60,000.00
	9	Kemper	5.57	do		June 27	27,696.80	12,000.00
	11	Amite	6.92	do		June 25	27,580.20	10,000.00
	13	Madison	4.27	Clay-gravel		do	20,967.43	8,000.00
	18	Rankin	3.83	Gravel	June 13		10,987.35	5,000.00
	27	Amite	5.80	do	June 14		25,201.00	10,000.00
	29	Union	6.00	Slag or gravel	June 13		33,564.96	15,000.00
Missouri	5	Scott	7.00	Gravel	June 5		39,353.50	9,813.37
	9	Jefferson	9.39	Gravel and macadam	June 26		47,630.05	23,815.02
Nebraska	2	Nemaha, Otoe, and Richardson	57.37	Gravel and earth		June 29	82,420.36	41,210.18
	3	Hall	32.25	Earth		June 22	39,848.16	19,924.08
	4	Cedar and Wayne	38.30	Sand-clay	June 26		89,044.91	44,522.45
	7	Kearney, Adams, Clay, and Nuckolls.	83.65	do		June 29	138,683.09	69,341.54
	10	Lincoln	19.11	Earth		do	43,027.97	21,513.98
	12	Logan and McPherson	17.10	do		do	36,215.92	18,107.96
	17	Lancaster	10.00	do	June 3		40,155.50	20,077.75
Nevada	8	Lyon	7.00	do	June 12		65,915.30	32,957.65
New Hampshire	13	Grafton	1.61	Gravel	June 4		15,980.25	7,990.12
	17	Rockingham	1.29	Bituminous gravel concrete	June 27		20,295.18	10,147.59
New Jersey	1	Salem	9.694	Gravel, concrete, bituminous macadam.		June 29	257,341.26	59,212.68
New Mexico	2	Mora	15.40	Crushed rock or gravel surface		do	108,067.61	54,033.80
	5	Quay	21.80	Macadam		June 22	89,101.68	44,550.84
	15	Dona Ana	11.50	Concrete	June 24		138,997.02	69,498.51
New York	2	Wyoming	2.59	Bituminous macadam		June 26	51,800.00	25,900.00
New York	3	Chenango	11.44	Bituminous macadam		June 26	223,800.00	111,900.00
	4	Chautauqua	4.30	Concrete		do	86,000.00	43,000.00
	7	St. Lawrence	3.48	Bituminous macadam		do	66,572.11	33,286.05
	8	Wayne	3.21	Bituminous macadam or concrete.		June 25	64,010.00	32,005.00
	9	Fulton	1.06	Macadam, tar surface		June 26	21,192.00	10,596.00
North Carolina	6	McDowell	7.69	Earth		June 14	40,921.43	15,000.00
	11	Lenoir	1.782	Concrete		do	35,973.04	10,000.00
	15	Guilford	14.55	Bituminous macadam		June 4	26,834.41	10,000.00
	19	Rockingham	8.21	Top soil		do	28,614.05	10,000.00
	22	Alamance	8.74	Bituminous macadam and concrete.	June 4	June 25	74,258.92	25,000.00
North Dakota	9	Grand Forks	3.58	Gravel		June 17	11,403.21	5,701.61
	11	Cavalier	7.64	Earth		June 29	9,281.42	4,640.71
	12	Barnes	29.51	Earth and gravel		do	48,122.67	24,061.33
	13	Stutsman	7.92	Earth		do	14,714.02	7,357.01
	16	Grand Forks	6.90	Gravel		June 22	26,032.91	13,016.46
	17	Griggs	17.70	Earth		June 29	20,268.49	10,134.24
	26	Benson	6.00	do	June 26		7,128.00	3,564.00
Ohio	19	Summit	16.70	Brick	June 3		761,117.50	165,000.00
	21	Guernsey	1.25	Concrete	June 26		29,400.00	12,500.00
Oregon	7	Marion	18.00	Bituminous macadam		June 29	394,643.70	180,000.00
	8	Union	6.00	Earth	June 4		13,917.75	6,958.87
	9	Baker	4.90	Gravel	do		41,926.50	20,963.25
Rhode Island	3	Washington	1.15	Bituminous macadam	June 26		40,918.35	11,500.00
South Carolina	5	Chesterfield	2.14	Gravel		June 26	12,505.02	5,955.51
	6	Marion	3.51	Bridges	June 26		54,678.53	27,339.26
Tennessee	3	Franklin	10.66	Water-bound macadam		June 22	84,145.52	40,000.00
	4	Moore and Bedford	12.27	do		June 29	99,474.76	49,737.38
Texas	3	Wichita	8.81	Bituminous gravel		June 3	85,916.79	42,958.39
	4	Travis	6.00	do		June 17	37,568.10	18,784.05
	29	Val Verde	4.905	Gravel		June 29	25,801.15	12,843.95

[1] Increased estimate over amount previously approved.

FEDERAL AID IN DETAIL FOR JUNE—Continued.

State.	Project No.	County	Length in miles.	Type of construction	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Texas	54	Walker	5.30	Gravel or macadam	June 7		$14,341.80	$87,170.00
	57	Willbarger	4.67	Concrete slab	June 5		97,137.05	46,353.45
	71	Grayson	1.77	Gravel	June 27		14,326.95	7,163.48
	72	Nolan	2.75	do	June 21		9,990.00	4,999.50
Utah	1	Carbon and Duchesne	44.89	Earth		June 29	131,132.10	65,566.05
Vermont	1	Addison	1.44	Gravel		June 18	17,015.09	8,507.54
	8	Caledonia	1.20	do		June 18	15,656.44	7,828.22
Virginia	3	Elizabeth City	3.45	Concrete		June 22	77,412.27	34,500.00
	7	Albemarle	3.163	Macadam		June 24	35,504.66	17,752.33
	8	Lee	0.043	Bridge		June 22	17,574.04	8,787.02
	9	Chesterfield	3.06	Concrete	June 21		69,017.39	30,600.00
	11	Lee	2.161	Water-bound macadam	June 24		42,103.70	21,051.85
Washington	11	Lewis	0.35	Bridge	June 8		120,432.40	60,000.00
West Virginia	2	Taylor	2.01	Brick on concrete base		June 24	53,333.50	9,000.00
	5	Monongalia	2.54	Concrete		June 25	50,895.90	18,000.00
	7	Wetzel	1.29	do		do	23,900.00	8,645.00
	15	Jackson	1.00	do		June 24	21,000.00	10,000.00
Wisconsin	2	Manitowoc	0.61	Concrete bridge		June 25	23,465.10	7,821.70
	3	Kenosha	1.50	Concrete		June 22	28,296.13	9,432.04
	5	Oconto and Marinette.	6.58	Gravel		do	32,240.35	10,746.82
	6	Oconto	3.01	do		June 26	14,321.36	4,773.79
	7	Waukesha	3.65	Water-bound macadam		June 22	30,749.07	10,249.69
	8	Dane	3.41	Concrete		June 25	75,761.35	25,253.78
	12	do	2.71	Water-bound macadam		do	30,925.84	10,308.61
	20	Langlade	6.21	Gravel		June 22	39,083.51	13,027.83
	21	Brown	3.80	Concrete		do	80,994.53	26,998.18
	23	Lincoln	4.15	Gravel		do	29,379.97	9,793.32
	25	Marquette	4.16	Topsoil		do	17,932.59	5,979.86
	26	Wood	2.82	Gravel	June 21		17,014.25	5,671.41
	27	Forest and Florence	6.29	Earth		June 22	22,012.32	7,337.44
	30	Kenosha	1.44	Concrete		do	27,875.93	9,291.98
	42	Rock	2.42	do	June 26		51,183.27	17,061.09
	46	Waushara	10.3	Earth	June 25		23,841.40	7,947.13
	47	Vernon	2.86	do	June 26		23,177.00	7,725.66
Wyoming	4	Niobrara	6.61	do		June 26	11,998.64	5,999.82
	10	Platte	1.21	Earth and 2 bridges.		June 22	5,572.16	2,786.08
	19	Natrona	39.09	Earth, sand-clay, and bituminous concrete.		June 27	219,349.44	109,674.72
	21	Lincoln	6.59	Earth		June 26	20,004.38	10,002.19
Total	135		1,448.601				10,220,236.91	4,215,640.74

COST OF NEW JERSEY ROAD SYSTEM.

State Highway Commissioner Thompson, of New Jersey, states that the entire highway system, as proposed by the Edge Road act will cost fully $30,000,000, and without taking into consideration the present war prices for labor and materials. He says that the $15,000,000 supposed to become available at the end of five years for the entire 655 miles of State highways will be much below the amount needed. In the original estimate made in 1916 the cost was placed at $16,000,000, with no allowance made for bridges, which were estimated at from $5,000,000 to $6,000,000. The legislature has since added two additional routes, increasing the cost $4,000,000. Other items add to the cost. The cost of materials has increased from 50 to 100 per cent and labor from 40 to 70 per cent.

FOR HIGHWAY IN FOREST PRESERVE.

The New York constitution restricts the building of roads in the State forest preserve. Existing roads run along the easterly and westerly borders of the Adirondacks, but do not pass through the preserve. An amendment to the constitution will be voted on at the November election to remove the restriction so as to permit the building of a State highway from Saranac Lake to Long Lake and thence to Old Forge, by way of Blue Mountain and Lake Placid. The road will have to be provided for by the legislature if the amendment is adopted.

WORK ON MAIN CALIFORNIA ROADS.

The main highway from Vallejo to Napa, Cal., will be completed and open for traffic by November 1, according to a member of the California Highway Commission. The part of the road from Vallejo County line is a first-class oil-macadam road, and from the latter point to Suscol it is paved. The portion under construction is that from Suscol to Napa, a distance of 4 miles. Work on the Jamison Canyon road from Cordelia to Napa, which has been closed all summer, promises to be completed so the road will be open for traffic during the winter.

MICHIGAN MOTOR LINES SERVICE.

The Michigan highways committee, appointed by Governor Sleeper, is working out plans for the development of intercity trucking and rural motor express service. Surveys are being made to ascertain the localities available for trucking. The return loads system is included in the plans. Motor trucking was already started before the organization of the committee and was steadily developing.

TO LIMIT TRUCK LOADS.

A bill is to be introduced into the Pennsylvania legislature this coming winter to limit the weight of loads which trucks may haul over the improved roads of that State.

STATE HIGHWAY MANAGEMENT, CONTROL, AND PROCEDURE.

By **M. O. ELDRIDGE**, Assistant in Road Economics, **G. G. CLARK** and **A. L. LUEDKE**, Engineer Economist of the Bureau of Public Roads.

WITH an aggregate length of some 2,500,000 miles, a normal annual expenditure of $300,000,000, a traffic which, expressed in horsepower, would probably exceed 125,000,000, the highways of the United States justify the most serious attention of the Nation in their construction, upkeep, and management. As each State looks after its own highways, there have developed 48 different varieties of highway management, and as in most of the States the task has been passed on down to the counties and even the townships, the development of highway management truly presents a "Joseph's coat" in the variation of method and design. It is manifest that among all these systems of management, varying as to intrinsic methods and defects and in the relative efficiency and inefficiency of their operation, much that is good has developed and much that is worthless may serve as a negative demonstration for future development.

In an endeavor to segregate the information which might prove useful in the further development of highway management, a very thorough investigation has been made during the past few years by the Bureau of Public Roads as to the organization, personnel, powers, and duties of the respective State and local highway management. The study has also included the classification of the highways and a study of the procedure followed in their construction and maintenance. The method of raising and expending funds for road purposes has also been prominently placed in the study.

A separate chapter has been prepared for each State in which the subjects are dealt with in the following order: Development and results of State participation and control of road work and the relation of State to local control; organization, personnel, duties, and powers of State and local road officials; classification of State and local roads with particular reference to control and basis of payment, including methods of selection, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by the State and local officials over construction and maintenance; sources of State and local funds, including bond issues, basis of allotment and apportionment of State funds, and the relation of State to local funds, and the amount available for road purposes during the latest calendar or fiscal year.

A chart accompanies each State chapter, visualizing the organization of highway departments, the personnel, duties and lines of responsibility and control over road affairs and the relation existing between the State and local forces.

Following the publication of State chapters and charts in "Public Roads," the results of the whole study will be presented in the form of tables, charts, and text so arranged and analyzed as to enable the reader to obtain a comprehensive knowledge of the subjects treated without reference to the State chapters except for details.

The chapters for the first 6 States are presented as follows:

ALABAMA.

DEVELOPMENT.

State participation in road improvement in Alabama consists of money aid to a State-wide system of State trunk roads and technical advice extended on request to local road officials, and is administered by the State highway department.

State interest in road improvement was first manifested in 1911 with the passage of a State-aid law which made the fund from the net earnings of State convicts available for distribution to the counties to aid in the construction of main thoroughfares. The State-wide system of trunk roads designated in 1915 by the State legislature and which comprises about 2,700 miles, or 5 per cent of the total road mileage of the State, now receives the aid extended by the State.

As this fund is limited in amount and the initiative in construction is taken by the county boards, the results so far with State aid comprise a series of systems of roads of local importance, instead of trunk roads connecting the various sections or important towns of the State.

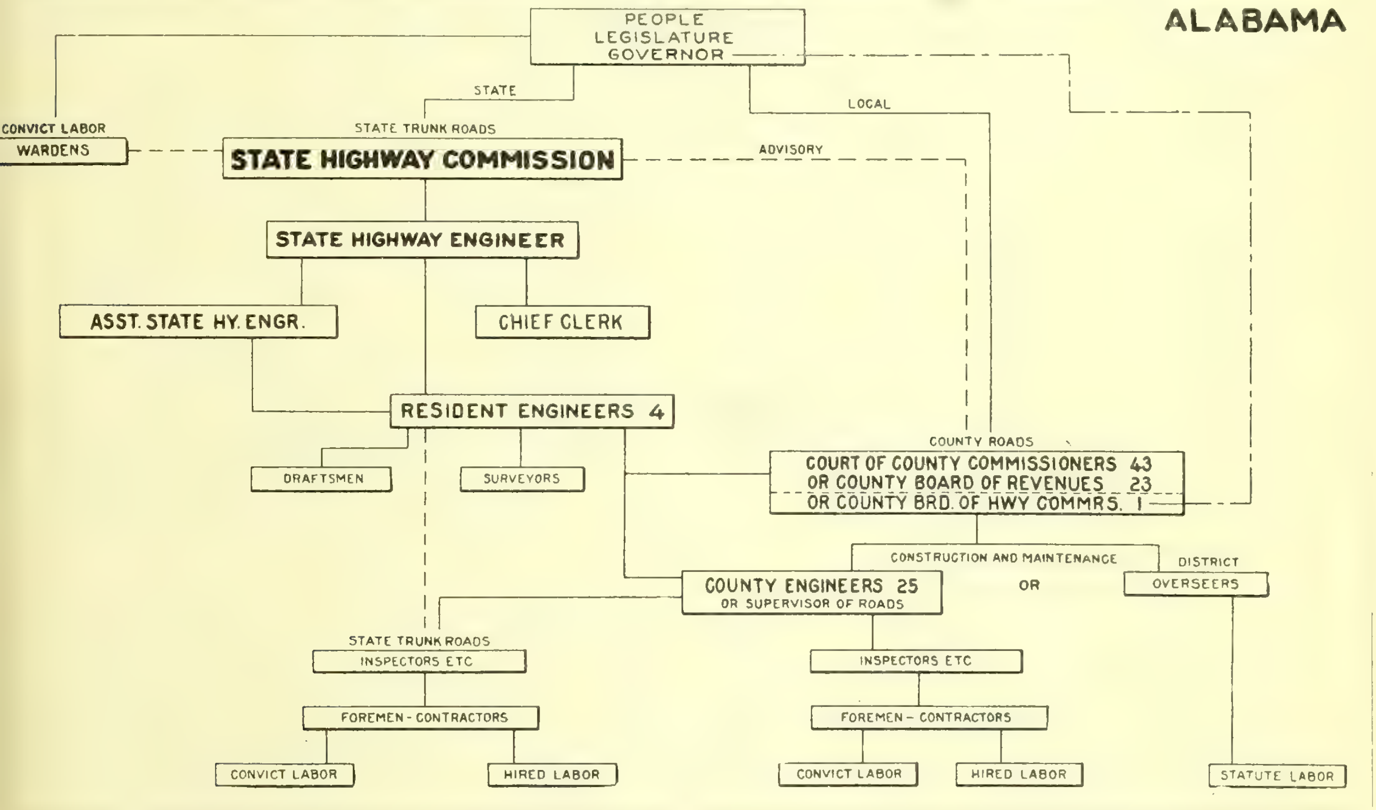
About 1,400 miles of the State system have been improved of which 659 miles had at the close of 1916 been improved by means of State aid. At the close of the same period about 6,000 miles or 10.8 per cent of the total road mileage of the State had been improved by surfacing, the cost having been borne in a small way by the State and the remainder by local funds.

Road and bridge expenditures during the year 1916 comprise $102,422 of State funds and $83,962 of local funds expended by or under the supervision of the State highway commission. During the same period about $4,000,000 of local funds over which the commission exercised no supervision was expended by local officials. In 1917 the total expenditure was $2,669,022. The Commission thus had jurisdiction over about 4½ per cent of the expenditures within the State for road and bridge purposes.

ORGANIZATION.

The road forces of the State and the relation existing between them is shown on this page.

State.—The State highway department is composed of a professor of civil engineering at the Alabama Polytechnic Institute, who is selected by the board of trustees of that institution, the State geologist, and three civilians appointed by the governor of the State for terms of four years. The chairman of the commission is elected from its membership. The State highway engineer elected by the commission is required to be a competent civil engineer experienced and skilled in highway construction and maintenance. He serves as the executive officer of the commission, its secretary, and is custodian of the records of the State highway department. Such technical assistants and clerical force as may be required are appointed by him with the consent of the commission. The State highway engineer has unlimited supervisory charge and may take active charge, with the consent of the local officials affected, over all matters pertaining to the improvement of a system of State roads, and he is required when requested by local officials to serve as an advisor over local road matters coming under the jurisdiction of the officials requesting his services. Other powers and duties of the State highway department are indicated on the chart in the appendix.



County.—County authority over road and bridge affairs in Alabama is vested in boards composed of officials elected by the voters of the county, or appointed by the governor. These boards in genera have broad powers over the roads under their jurisdiction.

In 43 counties of the State the governing board designated the court of county commissioners is composed of a probate judge as chairman, and one commissioner from each of the four districts of the county. All members of the board are elected by the qualified voters.

In 23 counties the governing board designated the county board of revenues is composed of five elective members. The chairman is elected from the membership of the board.

In one county the governing board designated as the board of county highway commissioners consists of five members appointed by the governor.

The county board as above constituted may employ a county engineer or supervisor of roads to act as the executive official of the board in road and bridge affairs coming under their jurisdiction, or they may divide the county into districts and appoint overseers who have charge of the work performed by statutory labor.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 55,446 miles of public road in Alabama are divided for the purpose of fixing responsibility for control, construction, and maintenance into three groups, namely, State trunk roads, county highways, and county roads.

State trunk roads comprise 32 routes with a total mileage of 2,700 designated by the State legislature. Roads of this group may be improved at the expense of the county or at the joint expense of the county and State. When at joint expense, application for State aid for a designated road or section thereof, and a certificate that the county's portion of the estimated cost is available, is made by the county board to the State highway commission. The application is examined by the State highway engineer and if deemed feasible and if the State's portion of cost is available, surveys, plans, specifications, and estimates of cost are made by the resident engineer detailed thereto, or by the county engineer under authority of the State highway engineer. The plans, specifications, and estimates when approved by the State highway engineer are transmitted to the county board with such recommendations as may be pertinent.

When the estimated cost exceeds $250, the work may be advertised for contract or executed by force account or convict labor. After 30 days' publicity, bids are opened in open session of the county board, which is attended by the State highway engineer or his representative. Contracts may be let to the owest responsible bidder, or all bids may be rejected and the work executed by convict labor or force account, under supervision of the county engineer or supervisor, or an engineer detailed by the State highway engineer. If by contract, the contractor files bond in double the amount of the contract. The bond must be acceptable to and approved by the State highway commission.

The work during progress is under the supervision and inspection of the county engineer or a resident engineer detailed by the State highway engineer if requested by the county board, and is subject to frequent inspection by the State highway engineer or his authorized representative. Monthly payments may be made covering 85 per cent of the completed work as evidenced by an estimate prepared by the engineer in charge of the work and approved by the State highway engineer, and transmitted to the probate judge, who draws a warrant on the county treasurer in favor of the contractor.

After $1,000 has been expended from county funds, the State auditor on order of the State highway commission draws warrant on the State treasurer in favor of the county treasurer for payment of the State's portion of the total cost.

Each 2-mile block of road as completed is inspected by the State highway engineer or his representative and, if satisfactory, is accepted. The payment therefor is made on receipt of final estimate prepared 30 days after the work has been completed. Final payment of the reserved 15 per cent and any other balance due is made in a similar manner.

County convicts may be employed or hired from or to, or exchanged with the governing board of another county for road building purposes, or State convicts may be employed under terms of a contract entered into by the county board and the State convict department. Roads of this group when constructed are maintained by the county with county funds under the instructions of and subject to the approval of the State highway engineer. When the county neglects or fails in its duty, maintenance is executed under direct supervision of the State highway engineer, the expense thereof being deducted from future allotments made to the county.

County highways.—Counties containing 200,000 or more inhabitants are required to maintain at their expense one public highway crossing the county in a northerly or southerly direction and one public highway crossing the county an easterly and westerly direction. Both roads are required to pass the county courthouse. Power is given to counties of this class to raise funds for this purpose.

County roads comprise all other public roads of the State and are located, constructed, controlled, and maintained by county boards with county funds. The State highway department has no jurisdiction over roads of this group unless requested to do so by the county officials having the proper jurisdiction.

REVENUES.

State funds for highway improvement are derived from the net proceeds of the State convict fund which amounts to about $154,000 per annum. A sum of $10,000 or $20,000 with the approval of the governor is set aside from this amount and used to pay salaries of the State highway department. The remainder of the funds is divided equally among the 67 counties of the State, and is used for construction of State trunk roads conditioned, however, on the county providing an amount equal to the allotment made. When the county provides funds in addition to the amount required, the governor may if an unappropriated surplus is found in the State treasury, allot additional funds to the county provided that the amounts so allotted do not exceed $4,000. All funds allotted by the State remain in the State treasury until disbursed on the order of the State highway commission.

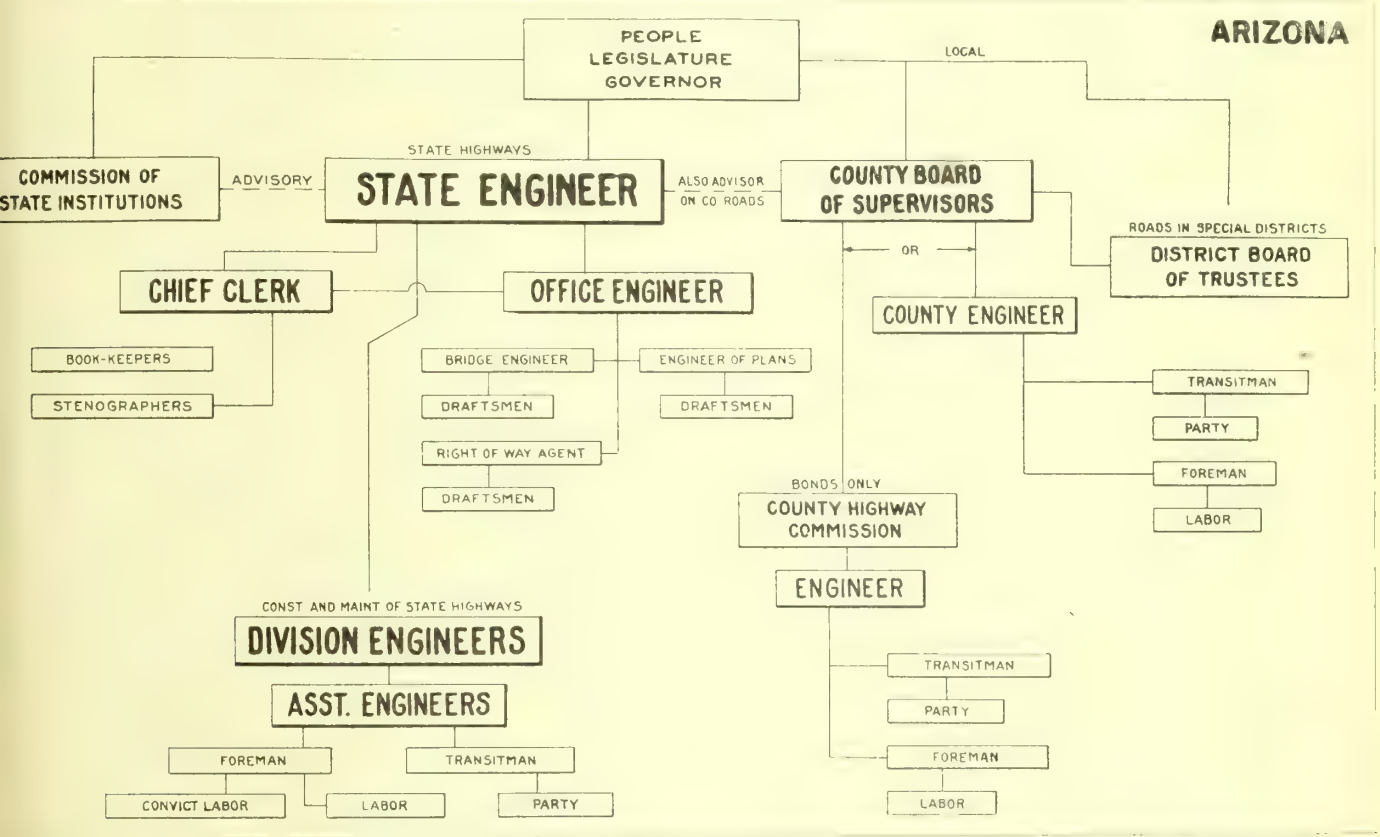
County.—The county road and bridge funds are secured from several sources:

1. All males between the ages of 18 and 45 and not otherwise legally exempt are required to labor on the public roads for a period fixed by the county board. This period may not exceed 10 days per

year, or in lieu thereof the board may exact a cash payment not to exceed $5.

2. The revenues accruing from a license tax which may be imposed by the county boards upon vehicles using the public roads, bridges, and ferries of the county.

3. Any surplus funds in the county treasury may by order of the county board be transferred to the road and bridge fund.



4. The proceeds of an ad valorem tax levied at a rate not to exceed one-fourth of one per cent on all taxable property in the county.

BONDS.

Bonds for road and bridge purposes may be issued by the counties in an amount not exceeding $3\frac{1}{2}$ per cent of the assessed valuation of the county and at a rate not to exceed 5 per cent. Before bonds are issued, the question must be submitted to the qualified voters of the county and a favorable verdict returned by a majority of the voters. The type and term of such bonds is not specified by State law.

ARIZONA.

DEVELOPMENT.

State participation in road improvement in Arizona is of recent origin, is effective in each county of the State, consists of money aid to the counties for construction of a system of State highways and technical advice and assistance rendered to local officials at their request, and is effected through the State highway department.

The highway law, effective in 1912, provided a fund for road construction, for the appointment of a State highway engineer, and the administration of this fund. This fund was divided by law as follows: Seventy-five per cent of the amount collected in each of the 14 counties constituting a separate fund to be administered by the State engineer with the approval of the board of supervisors of the county concerned, and 25 per cent of that collected in all the counties constituting a fund to be administered by the State engineer with the approval of the board of control. These funds are provided by a State-wide tax of 1 mill. At that time the board of control was composed of the governor, the State auditor, and a civilian member appointed by the governor. This board was replaced in 1917 by the Commission of State Institutions, consisting of three appointive members.

A system of State highways comprising about 13 per cent of the total mileage of roads in the State has been designated by the county boards, with the approval of the State highway department, for improvement under the direction of the State highway department with funds allotted by the State and provided by the county boards.

On January 1, 1917, 375 miles, or about 3 per cent of the total road mileage of the State, had been improved. Of this total all but 3 miles had been improved under the State-aid plan.

Arizona is sparsely settled and has at its disposal a limited amount of funds for the improvement of roads and bridges essential to the development of the resources of the State. However, soil and climatic conditions are of such nature in a major portion of the State that road construction and maintenance can be carried out under less expensive methods than are required in many sections of the United States.

In 1916, $441,202 of State funds (including allotments to counties) was expended by or under the supervision of the State highway department. This amount is included in the total expenditure of $1,988,221 made by State and local forces for road and bridge improvement during that year. In 1917 the total expenditure from all sources was $1,569,422.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown by the accompanying diagram.

State.—The State highway department is administered by the State engineer, who is appointed by the governor for a term of two years. He is assisted in the central office by an office engineer, in charge of engineering matters, and a chief clerk, in charge of accounting, correspondence, and records. The necessary force of technical assistants, stenographers, and clerks is appointed and their rate of compensation fixed by the State engineer.

For administrative efficiency and convenience the State is divided into four engineering districts, each administered by a division engineer, who reports to the State engineer and represents him in all highway work, either advisory or supervisory, in his district. Division engineers are provided with assistant and resident engineers, who serve as chiefs of survey and location parties, and as engineers in charge of construction.

The State highway department has charge of the construction of all work financed wholly or in part with State or Federal funds, and is required to serve in an advisory capacity to local officials or to detail capable technical assistants to take charge of and superintend local work when so requested.

County.—Counties in Arizona are governed by boards of supervisors, each composed of a chairman and two members elected for terms of two years. The clerk is appointed by the board, and the county treasurer, an elective official, is its fiscal agent. The board so constituted has charge of all road and bridge matters in the county where county funds are used and has the power within statutory limits to levy taxes, expend the proceeds, and to establish, open, and construct roads and bridges. Each county has appointed a county engineer, who, subject to the orders of the board of supervisors, is the administrative official in charge of all road and bridge work instituted under their direction. All county boards have, on request of the State highway department, arranged to keep records of their road and bridge expenditures in accordance with the cost accounting system used by the State highway department, thus providing a means of readily comparing the costs of similar classes of work throughout the State.

County Highway Commission.—On petition of 15 per cent of the tax-paying voters of the county, addressed to the county board, requesting that the tax-paying voters of the county be permitted to vote on the proposal, to issue bonds for highway improvement, the county board is required at least 90 days before such election to appoint a highway commission, consisting of five menbers, residents of the county. The commission is required to investigate all roads named in the petition and to prepare plans, specifications, estimates of cost, and a full report on all roads of the county or on each road or roads specifically named in the petition and cause the same to be published at least 20 days before the election. The proceeds of the bond issue, if authorized, are at the disposal of the commission, which has full powers over construction and may cooperate with the State highway department to secure Federal or State aid.

Special district trustees.—Under certain statutory requirements a board of three trustees may be elected by the voters residing in a district not exceeding 10 miles in length and 1 mile in width. This board has charge of all road work in the district.

CLASSIFICATION, CONTROL, AND PROCEDURE.

For the purpose of fixing responsibility for control, construction, and maintenance, the 12,075 miles of public road in Arizona are divided into two groups, State highways and county highways.

State highways comprise about 1,600 miles of public road selected with the approval of the State engineer by the boards of county supervisors for improvement under the direction of the State department with funds provided by the State road fund. When a project has been approved by the State engineer, surveys, plans, specifications, and estimates of cost are prepared under his direction, and when approved are forwarded to the county boards of supervisors for their consideration and approval. In actual practice the State engineer exercises at his discretion the authority vested in him over the expenditures for roads of this group. In specific instances the counties have provided in addition to the sum or sums allotted by the State sufficient funds to complete a project in a satisfactory manner. Construction is carried out by force account consisting of convict or paid labor under the general supervision of the division engineer and his assistants. Convict labor when allotted to counties with the consent of the commission of State institutions, together with the special funds provided therefor, is often used in conjunction with the portion of the 75 per cent fund accredited to such counties. Contracts for public works are prohibited by State law in Arizona. When the work is executed by force account, semimonthly pay rolls and expense vouchers are submitted to the State engineer, who, in conjunction with the commission of State institutions or the county supervisors, provides for the payment from the funds allotted to the project. The completed roads are maintained by the State, using either the 25 per cent fund or the 75 per cent fund, whichever may be available at the time the work is required.

County highways.—County highways comprise all other legally designated highways of the State. They are opened, constructed, and maintained by the counties with county funds or by the highway commissions or district boards of trustees, if such organizations exist within the county. A large number of trails are used as highways, but not having been officially designated by the county board as highways, county funds can not be expended thereon.

REVENUES.

State.—A State-wide tax is levied at the rate of one mill on each dollar of valuation on all taxable property in the State. The proceeds of this tax are divided into a 75 per cent fund for allotment to the counties and a 25 per cent fund for the use of the State highway department. The 25 per cent fund is increased by the revenues accruing from the operation of the motor vehicle license act. The 1 mill State tax produced about $686,000 in 1917 and the motor vehicle act produced about $125,000. There is also a special fund amounting to $65,000 per annum for the expenses incurred in highway construction with the use of convict labor. These funds are all available for the support of the State highway department, for allotment to meet Federal aid funds, and for the construction and maintenance of highways and bridges.

The method of handling these funds and of making appropriations from them differs according to the fund from which the money used is to be drawn and in the following manner: All projects that are to be paid for out of the 25 per cent portion of the State road fund, out of the motor vehicle license tax, or out of the special fund for the use of convict labor, must be approved by the State engineer and the commission of State institutions. All payments under such project must also be similarly approved.

The allotment to each county from the 75 per cent portion of the State road fund is made by law and amounts to 75 per cent of the State road tax collected in that county. All projects to be paid for from this fund must be approved jointly by the State engineer and the board of supervisors of the county concerned and all payments under such project must be similarly approved.

On some projects where funds are used from both 75 per cent fund and 25 per cent fund, the project is approved by the State engineer, commission of State institutions and board of supervisors of the county concerned and any specific payment is made with the approval of the State engineer and either the commission of State institutions or the board of supervisors of the county concerned, according to the fund from which payment is made.

County.—Additional funds for the counties to be expended under the supervision of the board of supervisors with the advice and assistance of the State engineer when requested are provided by a tax levied at a rate not to exceed 25 cents on the $100. A $2 poll tax is levied on all male inhabitants between the ages of 21 and 60, residents outside the limits of cities, towns, and villages, and who are not otherwise legally exempt. Highway commissions and boards of trustees for districts also have power to levy special taxes for road purposes within their jurisdiction.

Bonds.—Bonds may be issued by the county boards of supervisors when authorized by a majority vote of the property tax paying voters and when a county highway commission has been legally constituted. The bonds are required to be of the serial type, bear not to exceed 6 per cent interest, and may not run longer than 40 years.

Sinking fund bonds bearing not to exceed 6 per cent interest, when authorized by a two-thirds majority of the property tax paying voters affected, may be issued by the trustees of a legally constituted special road district or the district may levy a special tax for a period not to exceed five years and at a rate not exceeding 75 cents on the $100.

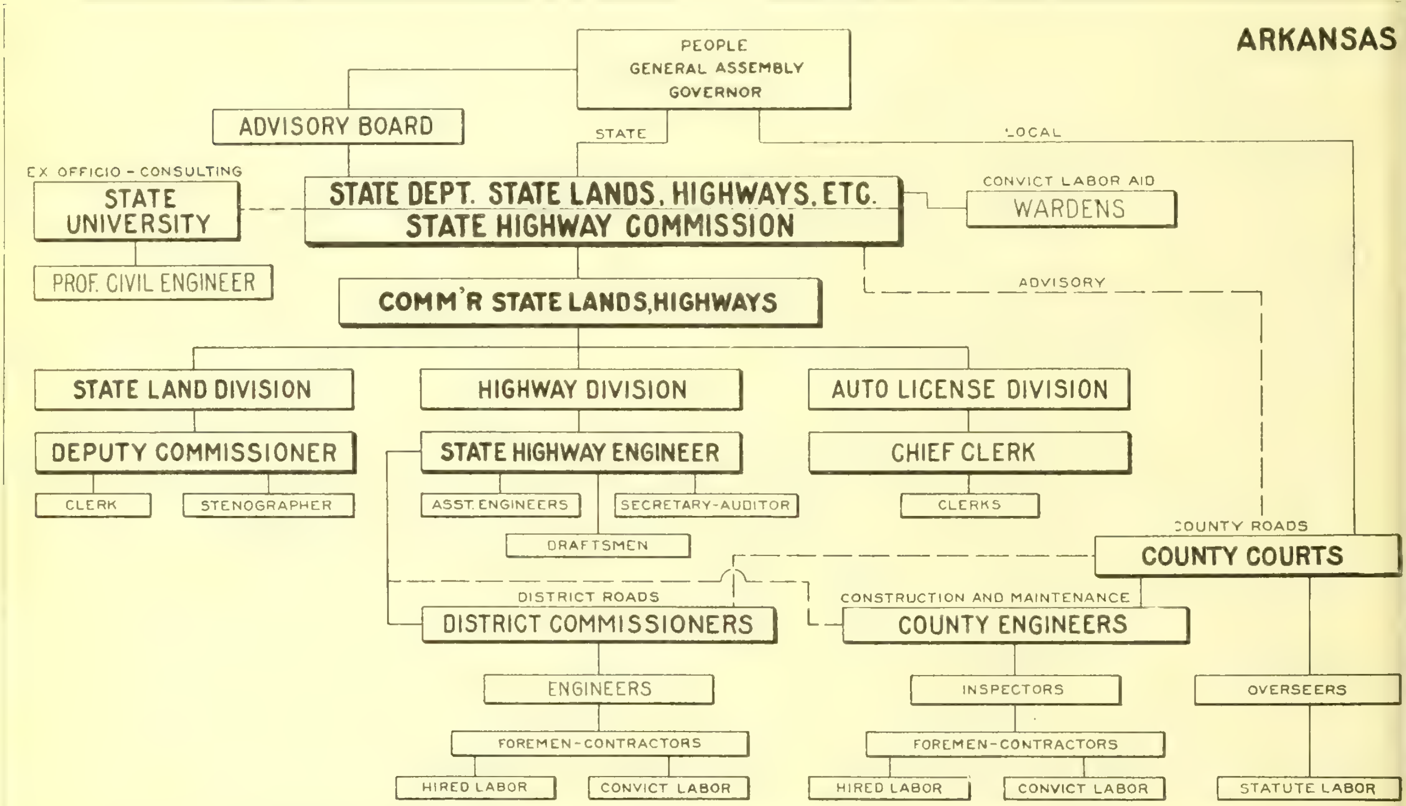
There were $295,000 of county road and bridge bonds outstanding on January 1, 1915.

ARKANSAS.

DEVELOPMENT.

State participation in road improvement in Arkansas is of quite recent origin, and of State-wide scope. The State highway commission, established in 1913 and limited to an existence of 30 years as a division of the Department of State lands, highways, and improvements, has jurisdiction by the terms of an act of 1913 over all State and Federal funds provided for State aid for road improvement of a system of State roads comprising about 6 per cent of the road mileage. The advisory board of the State highway commission, however, is required to recommend the amount of funds to be expended by the State on each particular project. Funds for State-aid purposes exceeding in amount funds provided by the Federal Government have been provided by the legislature.

Prior to 1917 the activities of the highway commission were limited to advisory and supervisory duties connected with projects financed by local funds. Considerable work in connection with the preparation of plans and specifications for roads, and more especially bridges, has been done by the organization at State expense for the benefit of county, township, and district improvement boards.



The laws require that all road or bridge improvements throughout the State, executed from special tax levies or bond issues, be constructed in accordance with plans and specifications prepared or approved by the State highway commission.

About 3 per cent of the road mileage of the State has been hard surfaced, the expense of construction being borne by counties, townships, or special districts. In 1916, the highway commission expended $55,483 on account of its duties as technical advisor of local officials, and supervised or furnished plans for work costing $1,683,549, which was financed from bond issues. The total expenditures for 1916 by all road forces of the State reached $3,443,887. Thus State supervision extended to 49 per cent of the total expenditures. In 1917 total expenditures were $3,335,262.

ORGANIZATION.

The organization of the highway forces and their relation to each other is shown by diagram.

State.—The State Highway Commission is a division of "The State department of State lands, highways, and improvements." The commissioner of this department, who is chairman, and two members appointed by the governor, compose the State highway commission. The chairman, subject to the approval of the commission, selects the State highway engineer, who is required to be a graduate civil engineer of some reputable school, and who is skilled in road building and surveying.

The head professor of civil engineering at the State university of Arkansas is ex officio consulting engineer of the department of State lands, highways, and improvements.

The advisory board of the State highway commission, limited to an existence of 20 years, is composed of the State highway engineer, the consulting engineer above referred to, and a member appointed by the governor for a term of two years. No State or Federal funds may be expended by the highway commission for road construction or improvement unless a specified amount therefor has been recommended by the advisory board.

The number and compensation of the regular technical assistants and other employees of the commission is fixed by law. Among the more important duties of the commission are the following: To prepare and approve plans and specifications of proposed improvements financed in part by State funds, and to supervise all such work during construction; to supervise maintenance of such work when completed; to prepare and furnish when requested by local officials plans and specifications for road improvement financed with local funds. To prepare a uniform system of blanks and to require local road officials to make detailed reports thereon at stated intervals and to investigate any road improvement or construction in progress in the State; and to make reports thereon to the governor should irregularities of administration or construction be ascertained.

The approval of the highway commission is required before the appointment of an engineer by a county or road improvement district becomes valid.

County.—The governing board of the county is the county court, composed of the county judge, all of the justices of the peace of the county, the justices being apportioned on a basis of one justice for each 1,200 qualified voters, constitutes the quorum court or levying court which levies taxes and appropriates funds for the use of the county court. However, no township may have less than two justices. These officials are elected for terms of two years. The county clerk and the county treasurer are, respectively, clerk and fiscal agent of the board. The county court is in charge of all road and bridge work of the county, appoints a superintendent of public dirt roads, creates road districts, and appoints overseers therefor. The county courts of six counties of the State are required to employ a county highway engineer, who is the executive officer of the court in all road and bridge work. The county court may authorize the creation or organization of special road improvement districts. The organization is made in accordance with statutory law, which requires the county court to appoint three members to constitute a governing board of the district. Districts when legally organized have the power to levy taxes, issue bonds, enter into contracts, and carry out construction. They may employ attorneys, engineers, etc.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The total mileage of roads in Arkansas is about 50,000, and for purposes of fixing responsibility for administration, construction, and maintenance, is divided into two groups, State roads and county roads.

State roads.—Comprising a system of about 3,000 miles of intercounty-seat roads, and such other rural post roads as may be designated by joint agreement between State and local officials. Roads of this class are constructed under State supervision by means of Federal or State funds combined with the local funds.

It is the intent of the highway act of Arkansas to distribute equally among the various counties of the State the funds provided by the Federal Government and by the State legislature. However, the funds at the disposal of the State highway commission are distributed only to counties or districts furnishing satisfactory evidence that the local organization is willing and able to bear its share of the cost of construction and the entire cost of maintenance when completed. The procedure is as follows:

The county court is required to present to the State highway commission preliminary surveys, plans, specifications, and estimates of cost which are required to have been made or approved by the commission and which bear the approval of the county judge, together with evidence that the road has been legally established and opened, that funds available to meet the county's share of the cost of construction, and that maintenance will be executed by the county after completion.

When aid is requested by a road improvement district, certified copies of all legal documents, publication notices, petitions, acts of the board of commissioners, bond of officials, and all legal steps taken from the inception of the district to the date of making the application, are required to be furnished to the commission in addition to the data required from the county. The county court is required to furnish certified copies of all notices or orders given by or under authority relative to the district or any official acts of the board, and to pledge the good faith and resources of the county to carry out maintenance when the road has been completed and become a part of the county system.

When the data provided by the county or improvement district boards has been approved by the commission, the application is presented to the advisory board which recommends to the State highway commission a specified amount of Federal or State funds for allotment to the project for construction purposes.

After the project has been favorably recommended by the advisory board, the local officials, county or district, present to the State highway commission a project statement showing in such detail as will enable the commission to ascertain, (*a*) whether the project conforms to the regulations of act 105 of the acts of 1917 (the State aid act), (*b*) whether adequate funds or their equivalent are available by or on behalf of the applicant, (*c*) what purpose the project will serve, and how it corelates with the other highway work of the county, (*d*) the administrative control of and responsibility for the project, (*e*) the practicability and economy of the project from an engineering and construction standpoint, (*f*) the adequacy of the plans and provisions for the proper maintenance of the road when constructed.

Each statement is required to be accompanied by a copy of the proposed contract and bond together with copies of all documents referred to therein, and a sketch map showing the general location of proposed project and all main contiguous transportation features. When an agreement has been arranged between the State highway commission and the local board, contracts may be let by the board under the following general conditions:

The local board is required to give due publicity before accepting bids for construction purposes. The bids are required to be submitted in such form as to show the unit price of the various services to be performed and of the materials to be furnished. Copies of the notices of publicity and of all bids received are required to be furnished to the State highway commission sufficiently in advance as to enable the commission, if it so desires, to have a representative present at the award of the contract.

If the contract is awarded to other than the lowest bidder, the State is not obligated to pay more than its pro rata share of the lowest bid unless proof be produced that the most advantageous offer was accepted. Copies of all contracts, including plans and specifications which were made a part of each contract, must be furnished the State highway commission as soon as it can be done conveniently.

Male convicts confined in the State penitentiary may be employed by counties or road improvement districts for road construction purposes, subject, however, to the rules and regulations of the State penitentiary commission and to the approval of the State highway commission as to time, place, and manner of such work. The pay of the warden and guards for such forces is borne by the State from the highway improvement fund. The other expense incurred in connection with utilization of the convicts for road construction purposes is borne by the county or district.

The engineer employed by the board with the approval of the State highway commission is in charge of the work during construction and is required to exercise strict inspection and supervision during the progress of the work.

Vouchers for partial payments at intervals of not less than one month and final payment when the work is completed are submitted by the proper county authority, the county judge, or the district improvement board to the State highway commission on forms supplied by the commission. Payments of the State's portion thereof are made by the chairman of the commission to the proper fiscal agent of the county or district.

The State highway commission requires that the board in charge of the work keep the records of such work in a manner prescribed by the commission, and the commission may at any time inspect such records, require certified copies thereof, and withhold payments for such portion of the work as has not been completed in accordance with the contract.

Maintenance is executed by the county with funds raised by the imposition of a three-mill tax and in accordance with the rules and regulations of the State highway commission.

County roads include all roads of the State not included in the State system. Such roads are under the county officials subject, however, to inspection of methods of construction and maintenance by the State highway commission.

County prisoners may be employed on road work with the approval of the county court having jurisdiction over them. Expense of feeding, clothing, housing, and superintending such prisoners is borne by the district when used under direction of the district board.

REVENUES.

State.—The State legislature appropriated for highway improvement purposes for the two-year period 1917 to 1919, $593,745.60 from the highway improvement fund. This fund is used for the support of the State highway commission and $496,134.60 of said amount for construction purposes. The highway improvement fund is accumulated from fees accruing to the State department of State lands, highways, and improvements. Fees for the registration of motor vehicles produce the greater portion of the revenue thus obtained.

County.—County funds are obtained from a highway and bridge tax not exceeding three mills on the dollar of assessed valuation. This tax is required to be paid in cash or county scrip. Four days labor or commutation thereof at the rate of $1 per day is required of each able-bodied male inhabitant not legally exempt.

Bonds.—Bonds may be issued by the board of commissioners of a district in an amount not exceeding 30 per cent of the assessed valuation of the district. Such bonds shall not bear interest at a rate exceeding 6 per cent. On January 1, 1915, $1,467,066 of indebtedness was outstanding. This total was composed of $217,140 of short time non-interest bearing scrip issued by counties and $1,249,926 of bonds issued by districts for terms of 12 to 20 years at a rate of 6 per cent.

CALIFORNIA.

DEVELOPMENT.

State participation in road improvement in California, dating from 1897, is now of State-wide extent and of considerable magnitude as regards expenditure of State funds, raised principally from the sale of bonds, and is administered by a well-organized State highway force.

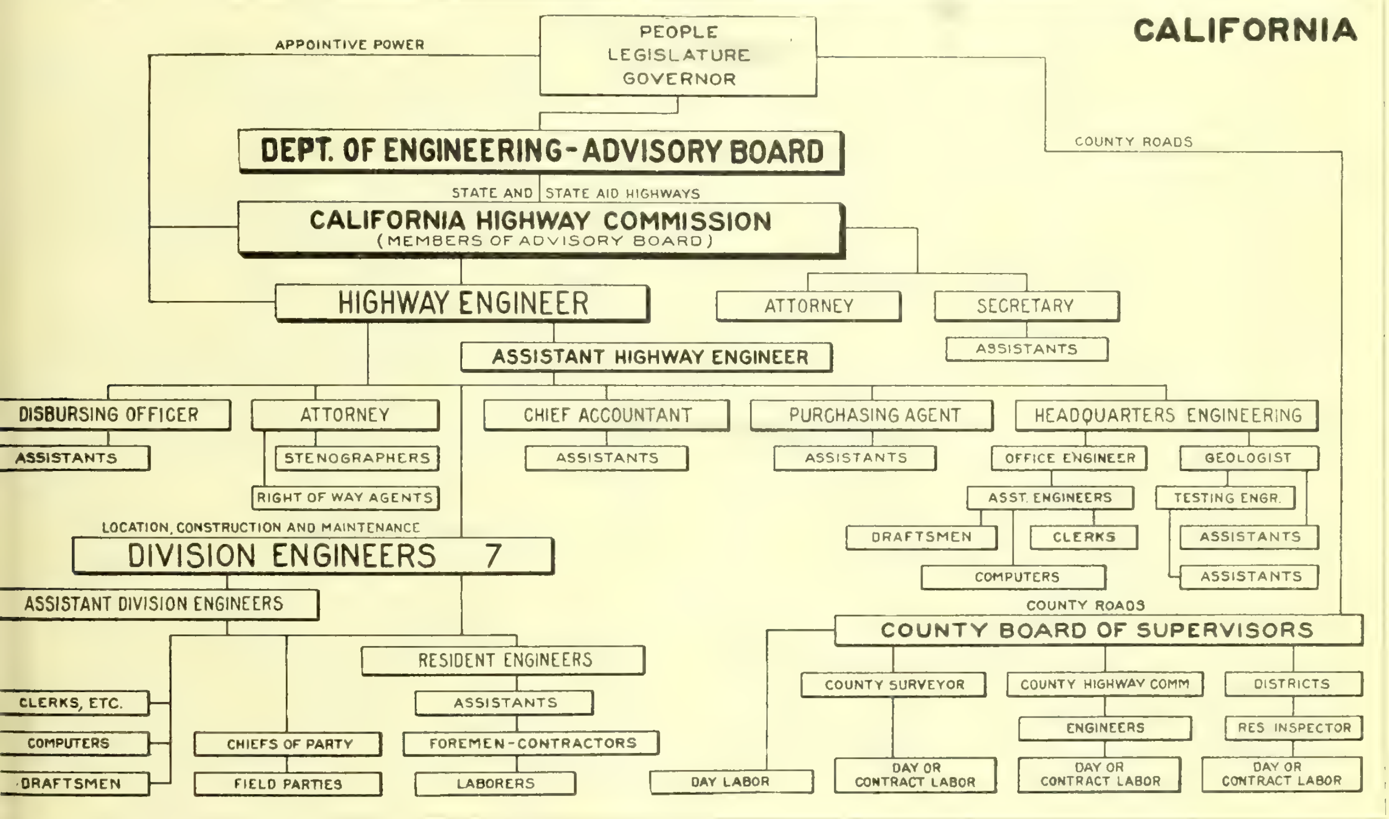
The State department of engineering, through its subdivisions, the advisory board and the California highway commission, forms the organization by which State funds are expended for construction and maintenance of State highways wholly built with State funds and such highways as are designated by the State legislature for State aid to counties improving prospective sections of the system of State highways and of other roads designated by joint agreement between State and local officials.

State bonds aggregating $33,000,000 have been authorized and the proceeds have been or will be expended on road construction extending throughout the State, principally on a State system comprising about 5 per cent of the total road mileage.

At the close of the year 1916, 20.2 per cent of the total road mileage of the State had been hard surfaced. In that year $4,285,964 was expended by or under the supervision of the State highway commission. The total expenditures during the year by State and local officials for road purposes amounted to $20,392,432, and in 1917, to $18,245,200.

Road improvement in California is well supported by both State and local funds and through the control exercised by the State department of engineering over location and types of construction by means of its right to extend aid to local organizations conforming to certain requirements, a well-planned and well-constructed State-wide system of improved highways is rapidly coming into existence.

The State of California agrees to become defendant in any or all suits brought against contractors engaged in road construction under State supervision on account of alleged infringement of patents involving types of roads under construction.



ORGANIZATION.

The organization of the highway forces of the State and the relation between the State and local officials is shown herewith.

State.—The State highway commission is vested in a department of engineering, consisting of an advisory board composed of ex officio members as follows: The governor as chairman; the State engineer, who is executive officer of the department; the general superintendent of State hospitals; the chairman of the board of harbor commissioners of San Francisco, and three members appointed by the governor. The three appointed members of the advisory board constitute the California highway commission, which ranks as a subdivision of the department of engineering. The advisory board is restricted by statute to the position of advisor to the highway commission in matters relating to finances, general policy, the general administration of the department, and in matters relating to location, securing of right-of-way, granting of aid to counties or districts, and the acceptance of roads constructed by local officials as a part of the State highway system.

The California highway commission, whose executive official is the State highway engineer, appointed by the chairman of the department of engineering, has charge of the construction and maintenance of all State road work, and of such other roads as may be placed under its control by local officials. The commission, in addition to such other duties as may be imposed upon it by law and the advisory board, is required to investigate the methods of construction and place the most approved methods at the service of the State; to compile and publish statistics relative to road system of the State; to advise with county or district officials relative to improvement work financed with local funds; to prepare plans, specifications, and estimates for and to supervise the cnstruction of such work when requested to do so by local officials, and to establish standards of construction suitable to the different sections of the State.

The commission has the power to require State, county, or municipal officials to furnish any information in their possession which relates to or is necessary for the proper performance of the duties of the department of engineering.

County.—County authority over road and bridge matters is vested in a board of supervisors consisting of five members elected for terms of four years, one from each district in the county. The board elects its chairman. The county clerk and county treasurer are respectively clerk and fiscal agent of the board. The county surveyor, who is an elective official, may be directed by the board to execute surveys and prepare plans, etc., for road improvement, and to act as an inspector on road work. The board has the power to establish roads, construct, improve, and maintain them, and to levy taxes to provide funds therefor. Each county supervisor is also road supervisor for the district represented by him. The county board appoints commissioners to take active charge of construction and repair of the roads in the various districts of the county. In certain cases the road commissioner is provided with two inspectors of different political affiliation. Maintenance by the county may be under the charge of a superintendent appointed by the board or may be let by contract.

Special boulevard districts may be organized in counties for road improvement purposes. The governing board of the district is known as the boulevard commission. Such commissions have broad powers over construction, location, etc., under some circumstances in the discretion subject to the general supervision of the State department of engineering. Bonds may be issued by such districts, or special taxes may be levied.

Special divisions of a county may be organized for similar purposes, and have similar powers as are designated for special districts.

CLASSIFICATION, CONTROL, AND PROCEDURE.

For the purpose of fixing responsibility for control, construction, and maintenance, the road system of California, comprising 61,039 miles, is grouped as follows: State highways, State-aid highways, State roads, and county roads.

State highways.—These are selected by the State legislature and comprise about 3,000 miles of road included in the coast route, and the valley route in the interior of the State both extending from Mexico to Oregon, and such branch lines as will connect with the county seat of each county. Such roads are constructed and maintained by the State with State funds. The counties, however, are required to assume the interest charges on the bonds the proceeds of which are expended in the county. The State department of engineering may, when the county is financially unable to bear this burden, reduce the amount of interest to be paid by the county.

Convicts confined in State prisons may be employed on the State highway system under the charge of and at the expense of the State department of engineering. The State board of prison directors has full jurisdiction at all times over the discipline and control of convicts so employed. Convicts may not be employed on any bridge work requiring the services of skilled labor.

State-aid highways.—This system comprises highways of local importance, or may comprise a portion of the State highway system. These roads are selected by joint agreement between the State department of engineering and the county boards of supervisors. They are improved by the counties under regulations and in accordance with standards approved by the State department of engineering. Initiative for improvement is taken by the county board, which petitions the State highway commission for financial aid. Such petition is required to contain data relative to location of the road, type of construction, statement as to status of proposed right of way, and such other information as the department may require. Surveys, plans, specifications, and estimates are prepared by county officials for the consideration and approval of the highway commission. All bridges, culverts, and right of way required by the proposed improvement, are secured by and at the expense of the county, and such expense is not considered as a part of the total cost of the highway under the State aid act. When the plans and specifications approved by the highway commission are returned to the county board, contract for the work is let by the county board of supervisors, and inspection is performed by the county engineer.

The total cost, comprising the cost of surveys, plans, inspection, and construction, is borne one-third by the State and two-thirds by the county. Payment of the total cost is made by the county board on presentation of estimates made by the engineer in charge and approved by the California highway commission. The county, when the work has been completed and accepted, presents bills to the State department of engineering covering the expense to be borne by the State. Payment of this account is made on order of the advisory board.

Completed roads are maintained by the county under State supervision and inspection, the cost being borne equally by the State and county.

State roads are special roads for which State funds are appropriated by the legislature, and are constructed and maintained by the State department of engineering under the direction of the State highway engineer. They are, as a rule, located in mountain counties which are unable to provide the necessary funds for their improvement.

County roads.—These comprise all other public roads of the State, are established, controlled, constructed, and repaired by county officials with county funds. They may be improved by the district or division organization, with local and State-aid funds, and when so improved may become a part of the State highway system, or be retained as a part of the improved county system.

REVENUES.

State.—Funds for highway purposes are derived from four sources and for the calendar year 1917 the following amounts were available:

1. Legislative appropriation for support of the highway branch of State department of engineering, $20,800.
2. Legislative appropriation for construction of certain specified roads and bridges, $6,000.
3. Proceeds of State bond issues, $1,300,000.

In 1910 $18,000,000 of 4 per cent bonds and in 1916, $15,000,000 of 4½ per cent bonds were authorized. They are of the serial type and $400,000 of the first issue are retired each year and $375,000 of the second issue are to be retired in 1923, and an equal amount in each year thereafter.

4. One-half of the net proceeds of the motor vehicle tax are available for maintenance of State highways, $1,247,269.

County.—Revenues for road purposes are obtained from the following sources:

1. Highway tax at a rate not to exceed 40 cents on $100 on all taxable property in the county.
2. One-half of the net revenues from the motor vehicle tax is divided among the counties in the ratio in which fees were collected.
3. From bond issues or special taxes levied for road improvement.
4. Refund from Federal Government of a percentage of the receipts collected in national forest reserves located in the county.
5. Fines and penalties accruing from violation of motor vehicle laws, when the arrest and conviction is executed by county authorities. Poll or head taxes are not levied in California.

BONDS.

State bonds aggregating $33,000,000 have been authorized as noted under "Revenues."

Sinking fund bonds in an amount not exceeding 5 per cent of the assessed valuation of a county or district, bearing interest at a rate not exceeding 6 per cent may be issued when authorized by a two-thirds majority of the voters of the territory affected.

County bonds may run 40 years, while district bonds are limited to a term of 20 years.

On January 1, 1915, there was outstanding $14,277,000 of bonded indebtedness for roads and bridges, issued by counties or districts.

ILLINOIS.

DEVELOPMENT.

State participation in road construction and improvement, while of comparatively recent origin, is extended throughout Illinois by means of aid to counties, and is administered by the department of public works and buildings, which possesses broad powers over location, standards of construction, and maintenance of all roads improved wholly or in part with State funds.

The State-aid system, which comprises about 18 per cent of the total road mileage of the State, is limited in extent by law to 15, 20, or 25 per cent of the road mileage of each county, the percentage being based upon the population of the county. On June 30, 1917, about 5.5 per cent of this system had been improved.

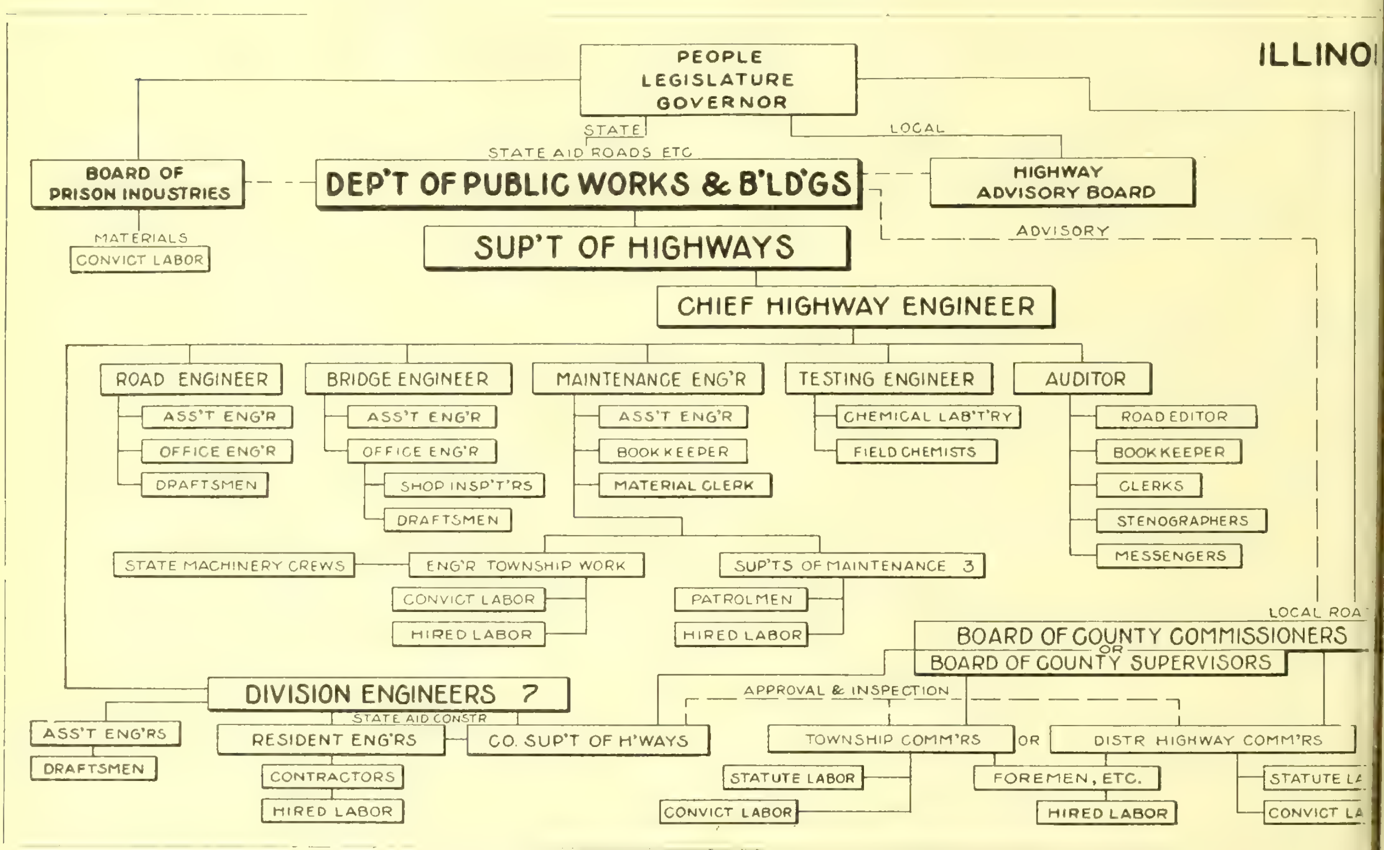
The voters of Illinois, at the general election this year, will pass on a constitutional amendment authorizing the issue of $60,000,000 of State bonds, the proceeds of which will be available for construction by the department of public works and buildings of a comprehensive system of State roads, comprising about 4,800 miles. The principal towns to be connected by this system are designated in the proposed law. The bonds, if authorized, will be sold as needed from time to time and will be of the serial type, limited to a life of 20 years. The interest and principal of this issue will be paid from the net revenues derived from motor-vehicle licenses.

At the close of 1916, about 12,400 miles, or 13 per cent of all public roads of the State, had been improved by surfacing. In 1916, $1,119,202 of State funds, and $1,503,953 of local funds were expended under the direct supervision of the State highway commission. The total expenditures for road and bridge purposes by State and local officials in that year reached $10,356,669. State supervision was thus extended to 25.4 per cent of the total expenditures, while the State contributions comprised 10.8 per cent of the total. A total of $10,083,728 was expended in 1917.

Considerable progress in road and bridge construction has been made under the State-aid plan and the State legislature has provided funds for the continuance of this assistance during the period 1917–1919.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the chart.



State.—Supervision over road affairs is vested in the department of public works and buildings, which is subdivided into several divisions with duties specified by law. The division in charge of road work is administered by a superintendent of highways, a chief highway engineer appointed by the governor with the advice and consent of the senate, and other subordinate employees, their number and compensation fixed by State law under a budget system.

The board of highway advisors, composed of five nonsalaried members, appointed by the governor with the consent and approval of the Senate, has advisory powers over the highway division of the department. It has access to all records of the highway division, may require written or oral information from any officer or employee thereof, and is required, when requested, to tender advice to the executive officials of the department, or it may of its own initiative recommend policies or practices for the consideration of the executive officials of the department.

The department of public works and buildings has full administrative control over the expenditure of the "Federal-aid" fund, composed of an appropriation by the State legislature and the funds allotted by the United States Government for road construction. The department has the right to prescribe rules and regulations not inconsistent with the law relative to the duties of its employees and of county superintendents of highways. It may undertake and supervise local construction when requested by local officials to do so, and on request is required to furnish plans, specifications, and estimates of cos of proposed improvements initiated by local officials.

The department has the necessary authority t prescribe a system of auditing and accounting covering all road and bridge matters handled by Stat and local highway officials and to compel account to be carried in such manner as may be indicated i the system.

County.—In 17 counties of the State county authority over roads is vested in a board of three commissioners, one being elected each year for a term o three years. The county clerk and the count treasurer are clerk and fiscal agent, respectively, o the board. In 85 counties of the State where township organization is in force, county authority i vested in a board composed of an elective supervisor from each township. Administrative supervision over road and bridge construction and maintenance is vested in a county superintendent of highways appointed by the board of supervisors from a list of eligibles certified by the department of public works and buildings. The county superintendent, while paid by and employed under the direction of the county board, is required to perform his duties in compliance with rules and regulations issued by the State department of public works and buildings.

District or township.—Counties not under township organization are divided into road districts. Each district is at least equal in area to a congressional township. Road affairs in the district are administered by a highway commissioner elected for a term of two years. Township road affairs are administered by a commissioner elected for a term of two years. The highway commissioner has general charge of the road and bridge improvements in his district or township when financed with funds raised by ordinary local taxation, and he has the power to fix, within statutory rates, both poll and property taxes.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 95,647 miles of public road in Illinois are divided for the purpose of placing the responsibility for control, construction, and maintenance into three groups.

1. Federal-aid roads, comprising about 586 miles of road selected by the department of public works and buildings with the approval of the United States Secretary of Agriculture, to be constructed under their jurisdiction by force account or contract with funds provided by the Federal, State, and local governments. Maintenance will be executed by and at the expense of the State. Convicts may be employed in the preparation of road materials for Federal-aid or State-aid roads.

2. State-aid roads comprise about 16,900 miles of road selected by the various county boards of commissioners with the approval of the department of public works and buildings. Of this, 920 miles were completed on June 20, 1917. These roads are constructed under State supervision by the counties in accordance with plans and specifications prepared by the department with funds provided by the State and county. Initiative for construction is taken by the county board which agrees to provide not less than 50 per cent of the total cost and requests an allotment of State funds. The type of road construction is selected by the county board or by the State department of public works from standard types established by State law and contracts are let by the department of public works and buildings. The work is carried out under the supervision of the division of highways, department of public works and buildings. The completed work is inspected and accepted by an agent of the department.

Maintenance is executed by and at the expense of the State, although sometimes carried out under the supervision of the county superintendent of highways, but in this instance he is considered a State official. However, when gravel or macadam roads are constructed, the county is required to pay one-half of the cost of maintenance, and when earth roads are constructed, the county is required to pay the entire cost of maintenance.

3. County or township roads comprise all public roads of the State not included in the preceding systems. Supervision of road and bridge construction and maintenance involving amounts of $200 or more is vested in the county officials. The responsibility for construction and maintenance of local roads and bridges is divided between the county and the district or township officials in such manner as may be prescribed by statute in special cases, decision or order of the county board, or by mutual agreement between the county board and the district or township board.

REVENUES.

State.—The funds available for expenditure by the State department of public works and buildings for road purposes are derived from the following sources:

1. Appropriation by the State legislature, $346,060 for the two years 1917 to 1919 for the expense of the highway division of the department of public works and buildings.

2. Appropriation of $1,326,000 for the same period for Federal-aid roads.

3. Appropriation of $1,200,000 for the same period and the reappropriation of the balance remaining on hand July 1, 1917, for State-aid roads. This balance on June 8, 1917, amounted to $1,173,979.07. Thus the State funds available for the 2-year period amount to approximately $4,000,000.

The funds provided for State-aid roads are allotted yearly by the department of public works and buildings to each county in the ratio that the road and bridge funds of the county bear to the total road and bridge fund of all the counties, provided, however, that in counties in which more than 40 per cent of the total amount provided by the State legislature for State aid is collected for the local road and bridge fund there shall be allotted to the county from State funds an amount equal to 25 per cent of the amount collected in such county.

The amounts allotted to the various counties of the State shall be used to defray not more than 50 per cent of the actual cost of construction. If the county fails within six months to provide an equal amount, the allotment is forfeited and is divided among the counties complying with the provisions of the State-aid law.

The fees received from licenses of motor vehicles and chauffeurs will be applied first to the payment of bonded indebtedness of the State and the interest thereon, when such bonds are issued and the remainder is deposited in the State treasury.

County.—Ordinary county revenues for road and bridge purposes are limited in amount, and are secured from a general levy for all county purposes. This levy may not be more than 45 cents on each $100 assessed valuation in counties having 300,000 inhabitants and 75 cents on each $100 of assessed valuation in counties having less than 300,000 inhabitants. The total tax levied for all purposes except to pay principal and interest of bonded indebtedness or judgments against the county, may not exceed 3 per cent of the total assessed valuation.

District or township.—Road and bridge revenues are derived from a direct property tax levied at a rate not to exceed 61 cents on each $100 of assessed valuation, and a poll tax not less than $1 nor greater than $3 levied on all male citizens between the ages of 21 and 50, not otherwise legally exempt. Townships and districts may transfer their road fund to the county for the purpose of securing and participating in State aid in road construction.

Bonds.—Counties, districts, and townships may, when authorized by a majority of the voters affected, issue serial type bonds of not more than 20 years' term in amounts not exceeding 5 per cent of the assessed valuation of the county, district, or township.

There was outstanding on January 1, 1915, $798,761.55 of local bonds and $3,656,500 of similar bonds were authorized but not issued during the year 1914. Interest rates on the outstanding bonds varied from 4½ per cent to 6 per cent.

GEORGIA.

DEVELOPMENT.

State interest and participation in road and bridge improvement in Georgia is of limited amount, dates from 1908, consists of convict labor allotted to the various counties under certain conditions, and of technical advice to county road officials and is administered by the State highway department.

By the terms of an act, approved in 1908, the State prison commission was required to allot the prisoners under its control to the various counties of the State, the allotment being based on the population of the counties and the convicts so allotted to be used for road construction purposes.

In 1917, 1,800,000 days of convict labor, valued at $2,700,000, were utilized by the counties on road work, about 6,000 convicts being employed.

In 1916 the State highway department, composed of the prison commission and three ex-officio members, was created and designated by the legislature as the proper body to cooperate with the Federal Government in the expenditure of Federal funds allotted to the State. As no State funds are provided for road purposes under the jurisdiction of the State highway department, its principal duty is to represent the various counties requesting Federal aid and to exercise supervision and inspection over work financed in part by Federal funds.

State convicts allotted by the prison commission comprise the principal road-building force of the State. This force is supplemented by statutory labor required of certain male inhabitants, cash taxes, and the proceeds of bond issues. Practically all work, except Federal aid work, is entirely in the hands of local officials and is constructed and maintained in accordance with such plans and standards as may be acceptable to the officials in charge.

The State highway department has designated a system of 5,500 miles, or 6.75 per cent of the total State mileage, for improvement with Federal and local funds under the supervision of the department. But as half of the cost is supplied by the counties, the initiative for construction lies in their hands, and they are thus able to control to a considerable degree the location of new improvements.

At the close of 1916 about 13,500 miles, or 15.3 per cent of the total State mileage, had been surfaced by and at the expense of the counties. The expenditures for road and bridge improvement throughout the State during the year 1916 approximated $3,750,000. In 1917 it reached $4,318,350.

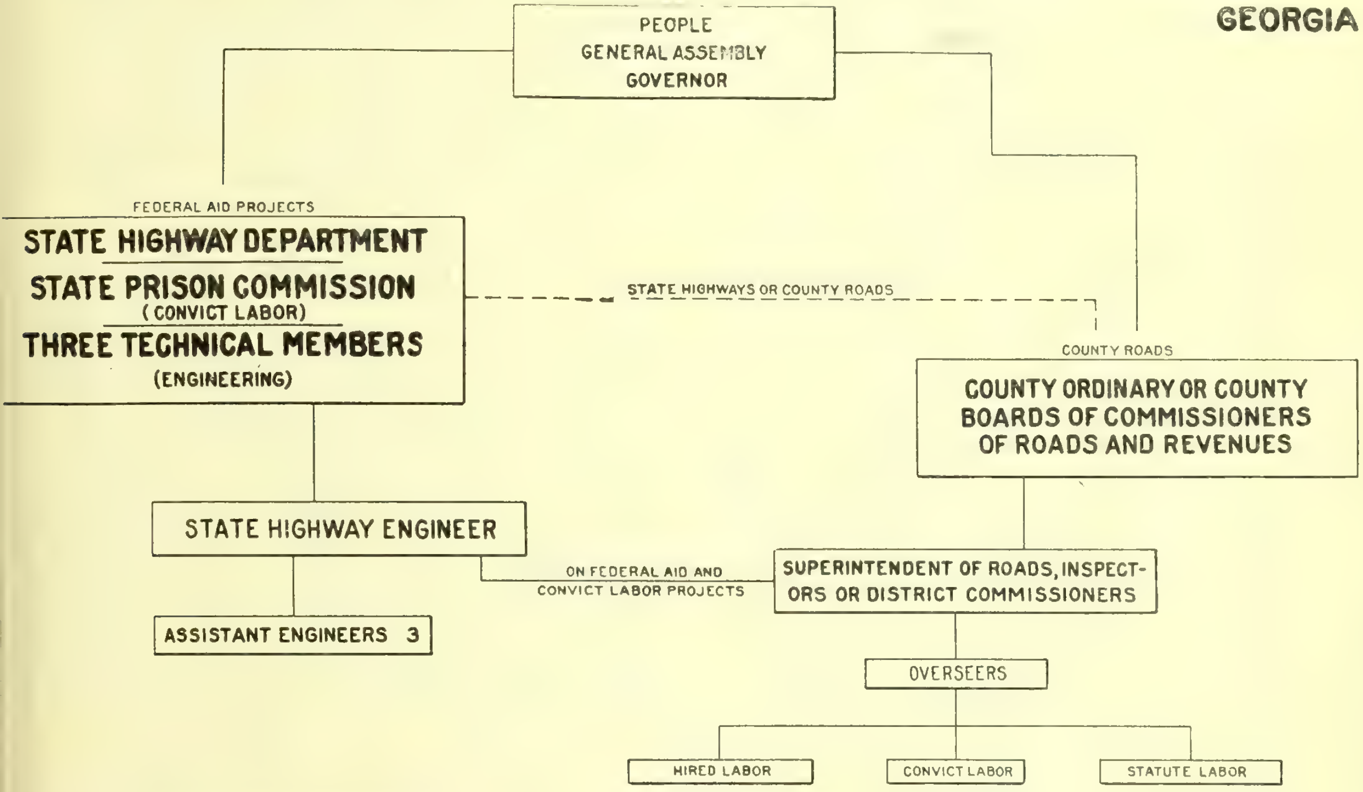
ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown in the diagram on page 51.

State.—The State highway department is composed of three ex-officio members, namely, the State geologist, the dean of the college of engineering of the State University, the professor of highway engineering of the Georgia School of Technology, and the prison commission, consisting of three members elected for terms of six years. The State highway department represents at their request the various counties of the State in negotiations with the United States Government regarding the expenditure of the Federal aid allotted to the State and is required to supervise such work while in progress. When the State highway department was created no appropriation was made for its maintenance, but the law provided that four supervisors, to be civil engineers, be employed by the prison commission and turned over to the highway department. A State highway engineer and three assistants are now so employed.

The prison commission employs inspectors who inspect camps, treatment of convicts, clothing, sanitation, etc., but they have nothing to do with road work.

County.—Administration of road and bridge affairs in the counties is vested either in an official termed "ordinary," or in a board of commissioners of roads and revenues. The ordinary is elected for a term of four years, and in addition to his road and bridge duties, serves as judge of the probate court.



Boards of commissioners are authorized by special acts of the legislature, or counties of certain qualifications may elect boards under the terms of a general act of the legislature. The membership of the board varies from one to eight elective members with terms of office ranging from two to six years. Because of the number of special acts and forms of procedure optional with the county authorities, a uniform organization of local road forces does not prevail throughout the State.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 80,669 miles of public roads in Georgia are classed as county roads of the first, second, or third class, dependent on the width of cleared right of way. Fifty-five hundred miles of this system have been designated for improvement under State supervision with Federal and local funds or with convict labor and local funds. Improvements executed with Federal aid are initiated by the county with the approval of the State highway department. Surveys, plans, specifications, and estimates are prepared by the department at the expense of the county, and when approved by the county authorities are transmitted by the State highway department to the Secretary of Agriculture for consideration and allotment of Federal funds. If executed by contract, contracts are let by the State highway department and the work is executed under the inspection of the department. Maintenance is executed by the county in accordance with the terms of the allotment of Federal funds and is subject to inspection by the department.

Roads of the above class or other county roads may be improved by the county with statutory or paid labor or by convicts allotted by the prison commission. The counties are required to pay all expenses incurred on account of the convicts.

All roads except those receiving Federal aid are administered by county authorities with county funds.

REVENUES.

No State revenues are available for expenditure in counties, State participation being limited to the allotment of State prisoners to counties.

County.—County funds for road and bridge purposes are secured in part from the apportionment by the State, of the net revenues from the registration of motor vehicles, on a basis of rural road mileage; from the imposition of an ad valorem tax at a rate not exceeding 40 cents on $100 of valuation of taxable property in the county for the public road fund and from the imposition of a tax at a rate of 10 to 25 cents on each $100 valuation for general road tax fund or in lieu of this latter tax, the county may require statutory labor, for a period not exceeding 15 days per year, of all able-bodied males between the ages of 16 or 21 and 50, not otherwise legally exempt. Statute labor may be commuted at a rate of 50 cents, 75 cents, or $1 a day, dependent on the special law adopted by the voters of the county.

Bonds.—These may be issued by a county when authorized by two-thirds of the electors. The amount may not exceed 7 per cent of the total assessed valuation of the county. The type and term and rate of interest are fixed by the county board or other body or official of concurrent duties. The total amount of bonds, issued by counties for road and bridge purposes outstanding on January 1, 1915, amounted to $127,500. Several issues have, however, been authorized since that date.

NEW COLORADO SCENIC HIGHWAY.

A new road which opens to the traveler Colorado scenery of great attractions, heretofore not accessible, has been completed after many months of work. It is the Phantom Highway, connecting the Cripple Creek district with the Arkansas Valley. The road runs from Canon City to Victor, a distance of 35 miles. Phantom Canon is entered 11 miles from Canon City, and for 20 miles the road traverses a magnificent panorama of mountain scenery. A little mountain stream fed from the snows of Pikes Peak runs through the canon alongside the road for its entire length and adds to the beauty of the scene. The Phanton Canon highway forms the western side of a great quadrilateral figure of which Canon City, Cripple Creek, Colorado Springs, and Pueblo form the angles. Each side of this figure now has a fine State highway. Although the road climbs to an elevation of nearly 10,000 feet the incline is so gradual that at few if any points does the grade exceed 4 per cent. The road was built under the supervision of the State highway commission and the commissioners of Fremont and Teller Counties.

TO KEEP ILLINOIS ROADS IN CONDITION.

Clifford Older, chief highway engineer of Illinois, has issued a circular letter calling attention to the importance of keeping the main arteries of travel at the highest possible point of maintenance, so as to be available for motor truck transportation. The State council of defense has also pointed out the necessity for the maintenance of designated State-aid roads and of roads to be improved by the proposed $60,000,000 bond issue, as construction is not expected to start until after the war, and that therefore it becomes a patriotic duty on the part of township commissioners to keep the main roads, whether dirt or otherwise, in good condition.

NEW INTERNATIONAL HIGHWAYS.

The Canadian Government has undertaken the construction of a series of what are termed "international highways," roads which will make connection with improved roads leading to centers of population in the United States. The first to be built will connect Hamilton, Ontario, with Niagara Falls. There is already an improved road between the Falls and Fort Erie, opposite Buffalo. Other roads to follow will be from Hamilton to Windsor and from Prescott to Ottawa. This is to be only the beginning. The plan was recently outlined to the farmers of Welland County, at their annual meeting, by a government official.

WAR PRISONERS FOR ROAD WORK.

In his report at the fifth annual meeting of the Dixie Overland Highway Association at Shreveport, La., August 14, the president, John S. Beecker, of Columbus, Ga., advocated that war prisoners and interned aliens be put at work on road construction.

○

OFFICE OF PUBLIC ROADS AND RURAL ENGINEERING ROAD PUBLICATIONS.

***NOTE.**—(Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free).*

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

BULLETINS.

(In applying for these bulletins the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28").

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation. 1916.

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*Department supply exhausted.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given, as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. (1911.) 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads. 5c.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. *239. The Corrosion of Fence Wire. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c.
*461. The Use of Concrete on the Farm. 5c.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given, as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10. No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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*Department supply exhausted.

A Message from the Secretary of Agriculture to American Farmers

TO THE PATRIOTS ON THE FARMS:

You are asked to undertake another offensive—to go "over the top" this fall for a great harvest of wheat in 1919. I need give only a few figures and facts to impress you with the increasing and urgent need of our people, our armies, the allied peoples and their armies for large supplies of American wheat.

Our reserve supply or carry-over from the 1917 crop is practically exhausted and is the smallest on record. The need of building up reserves of wheat is evident. Although this country produced a small crop of this grain in 1917, the total exports of wheat in excess of imports, including flour in terms of wheat, amounted to approximately 100,000,000 bushels for the year ending June 30, 1918. This is in comparison with 178,000,000 bushels exported in 1917, 236,000,000 bushels in 1916, and 331,000,000 bushels in 1915. It was possible for the United States to export wheat in large quantities in 1915 and 1916 only because of the large wheat crops of 1912–13–14–15, which gave this country an accumulation of stocks of this grain. Both the 1916 and 1917 crops were smaller than any crops since 1911, and besides this there was a greater demand for seed wheat and an increased population to be fed.

Moreover, it must be borne in mind that the carry-over in all the ten importing countries in Europe was practically exhausted this year before the new harvest; that the normal requirements of the exporting countries are increasing instead of diminishing; that some losses in storage and transit may be expected to continue; and that it is highly desirable that a surplus should be accumulated as insurance against partial crop failure next year.

You have been asked to sow to winter wheat this fall not less than 45,000,000 acres—an increase of 7 per cent over last year's sowing—and the department has suggested that an even greater area, 47,500,000 acres, is desirable. The increased planting asked of each State has been carefully determined with regard to its local conditions and its reasonable capabilities. Your county agent can tell you the quota assigned to your State and you can apply the responsibility to your case.

You have occupied and do occupy the first line trenches of the food army. You have to fight difficulties too. I am not unmindful of these. In the Department of Agriculture we consider them daily, and daily we give our best efforts to help you meet them. You know of the difficulties in your community, but I know of them in many communities of many States, and so seriously do they impress me that I might almost consider them insurmountable had not American farmers last year, and again this year, revealed the true American fighting spirit and ability to meet serious situations. They will not let the war fail because of deficient food production.

Let us sow liberally for a big harvest in 1919. It has been called the Liberty Wheat Harvest. We all hope it will be. But let us undertake the task with the determination that we will sweat our blood for many more if need be before we yield one measure of our freedom to a Prussian domination. Let us fight in the furrows.

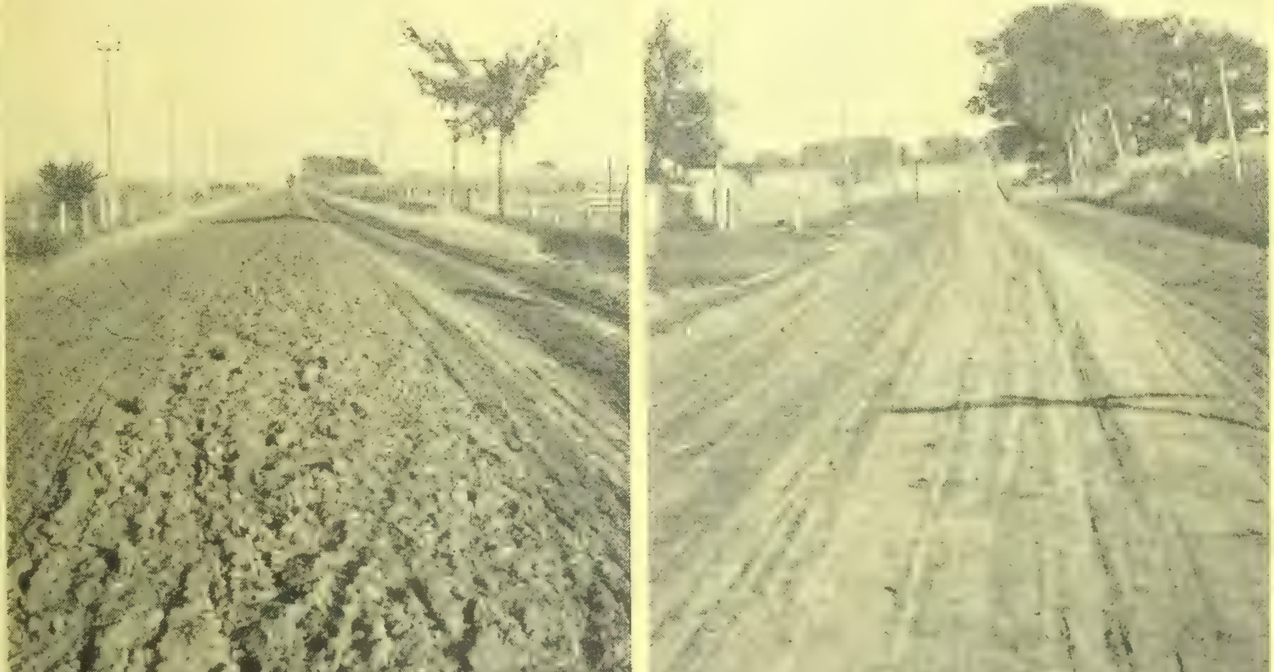
D. F. Houston

Secretary of Agriculture.

U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 5 WASHINGTON, D. C. SEPTEMBER, 1918



NOT OILED—WHAT OIL DOES FOR EARTH ROADS—OILED

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1918

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both houses of Congress. Others desiring to obtain PUBLIC ROADS can do so by sending 15 cents for each number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

It is the desire of the Bureau of Public Roads and the Government Printing Office to issue PUBLIC ROADS regularly each month, but it must be borne in mind by the readers that in these war times the tremendous volume of emergency printing takes precedence in the Printing Office and due allowance be made for delays.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1918

BUREAU OF PUBLIC ROADS

Logan Waller Page . . . . Director
P. St. J. Wilson . . . Chief Engineer
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REINFORCED CONCRETE SLAB BRIDGE DESIGN BASED ON FULL SIZED TESTS

By A. T. GOLDBECK, Engineer of Tests, Bureau of Public Roads.

THE past winter has witnessed the failure of many types of road surfaces due to the extremely heavy truck loads they have had to carry. Such loads, except for the occasional traction engine and roller, were unheard of when these roads were built, and adequate provision for them was not made in their design. Highway bridges in general have fared somewhat better than the road surfacing, but when we see the inadequacy of the roads to carry heavy loads we should not be surprised at the very natural queries, "What about the bridges?" "How long will they continue to carry these increasingly heavy loads, and what is the greatest load they can safely carry in the future?" The present discussion will treat of a particular phase of these questions, that dealing with reinforced concrete slab bridges.

The ability of wide, thin slabs to support heavy concentrated loads, and the proper procedure in their design were matters of great uncertainty up to a few years ago, when several laboratories almost simultaneously investigated the subject. Now, however, sufficient tests on full size slabs are available to permit reliable calculations being made. Many tests have been carried on by the Bureau of Public Roads, by the University of Illinois, and the Ohio State University, to investigate how to design a slab subjected to concentrated loads. Some of these tests will be described briefly, and practical rules for applying results will be given.

AIM OF TESTS.

A thin, flat slab when loaded with a concentrated load differs from a narrow beam in that only part of the slab width is effective in carrying the load, whereas the entire width of a narrow beam is brought uniformly into play. The thin, wide slab with a load applied at its center is stressed most where the load is placed, and the stress decreases to each side and vanishes if the slab is very wide, in a curve as shown in figure 1. Narrow rectangular beam theory has been well established, and the data obtained in the tests of wide slabs was readily applied to this theory for the formulation of a suitable basis upon which to design wide slabs.

HOW THE SLABS WERE INVESTIGATED.

In all of the slab tests at the Bureau of Public Roads the method of procedure was to apply known concentrated loads on the slab specimens which rested on two supports. The deformation of the steel reinforcing and concrete, and also the deflection were measured. These deformations or changes in length in the slab were always taken at the "dangerous section," where they were greatest. In a few cases, deformations were also measured over the entire area of the slab. A strain gauge capable of measuring changes of 0.0002 of an inch was used in all of the tests, and in addition, the vertical deflections of the slab were obtained, generally by means of a micrometer head reading to 0.001 of an inch.

DATA ON SLAB TESTS.

Slab No.	Dimensions.		Depth.		Steel percentage.		Central load, effective width ÷ span.	Failure	
	Span.	Breadth.	Total.	Effective.	Longitudinal.	Transverse.		Span.	Central load
	Feet.	*Feet.*	*Feet.*	*Feet.*					
679	11.5	6	7	6	0.77	....	....	11.5	21,500
705	6	7	5	4	.91	....	0.9	....	....
706	3	7	5	4	.91	0.41	....	3	42,800
730	5	7	6	5	.91	....	1.1	6	21,700
	6	....	....	....	....	....	.96	....	....
736	6	7	4	3	.60	....	....	6	7,560
737	5	7	7	6	.75	.33	1.2	6	34,200
	6	....	....	....	....	....	1.2	....	....
835	16	32	12	10½	.75	....	(1)	16	119,000
930	16	32	10	8½	.75	....	(1)	16	80,000
934	16	32	7	6	.75	....	(1)	16	40,000

[1] See next table.

EFFECTIVE WIDTHS UNDER CENTRAL LOADS.

Center load.	Slab 835: 10½ inches effective depth.	Slab 930: 8½ inches effective depth.	Slab 934: 6 inches effective depth.
15,000	....	11′.4=71.6 per cent span.	12′.7=79.5 per cent span.
20,000	11′.6=72.3 per cent span.	13′.0=81.2 per cent span.	17′.5=109.3 per cent span.
25,000	11′.5=71.9 per cent span.	12′.9=81.1 per cent span.	....
32,500	12′.1=75.7 per cent span.	....	....
35,000	....	14′.5=90.7 per cent span.	....
Failure	119,000 pounds	80,000 pounds	40,000 pounds.

THEORY USED FOR APPLYING RESULTS.

Consider first a wide slab supporting a single load concentrated at its center. Measurements of deformation show that the load deforms the central part of the slab as shown in the curve in figure 1. The maximum deformation occurs under the load, and as the sides of the slab are approached the deformation becomes smaller.

This curve of deformation is the same in shape for both the steel and concrete. A little thought will show that the resisting moment of any slab is directly proportional to the area of the curve of unit deformation. Two similar slabs stressed to have the same area of unit deformation, even though their unit deformation curves are dissimilar in shape, exert equal resisting moments. Suppose one slab is stressed as in curve JHF, and the other as in rectangle BIGD, and both have the same area and the same maximum ordinate CH. A slab of width BD stressed constantly throughout its width is then equal in strength to a similar slab stressed as in the curve by a single load at its center. The width BD is commonly called the "effective width" of the slab and this is the width of the slab which may be considered as carrying the entire concentrated load. When the value for this width as determined by test is substituted in the common formulas for narrow rectangular beams, these formulas may be directly applied to the design of wide slabs.

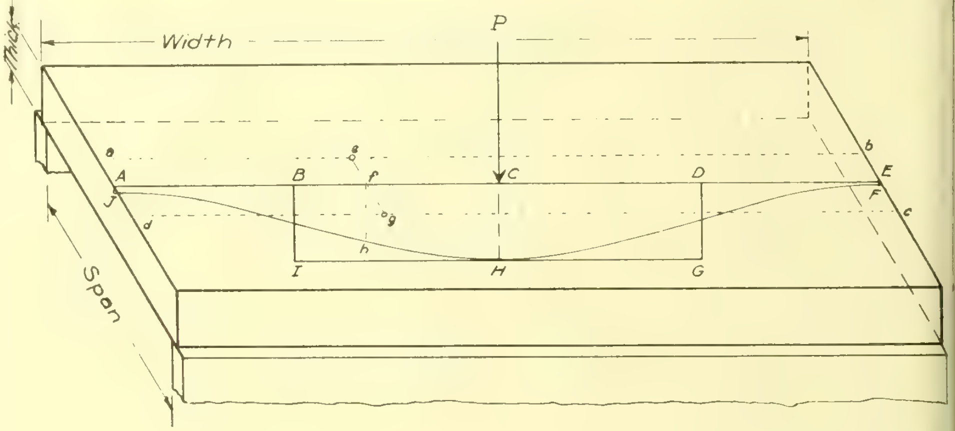


FIG. 1.

A number of slabs have been tested as outlined above, and their effective widths have been obtained from the deformation curves, first, by getting the areas included between these curves and their base lines, then dividing these areas by their maximum ordinates. When the load is placed in the centers of the slab and the width of the slab is more than about twice the span length, the effective width may be considered as equal to seven-tenths of the span length of the slab.

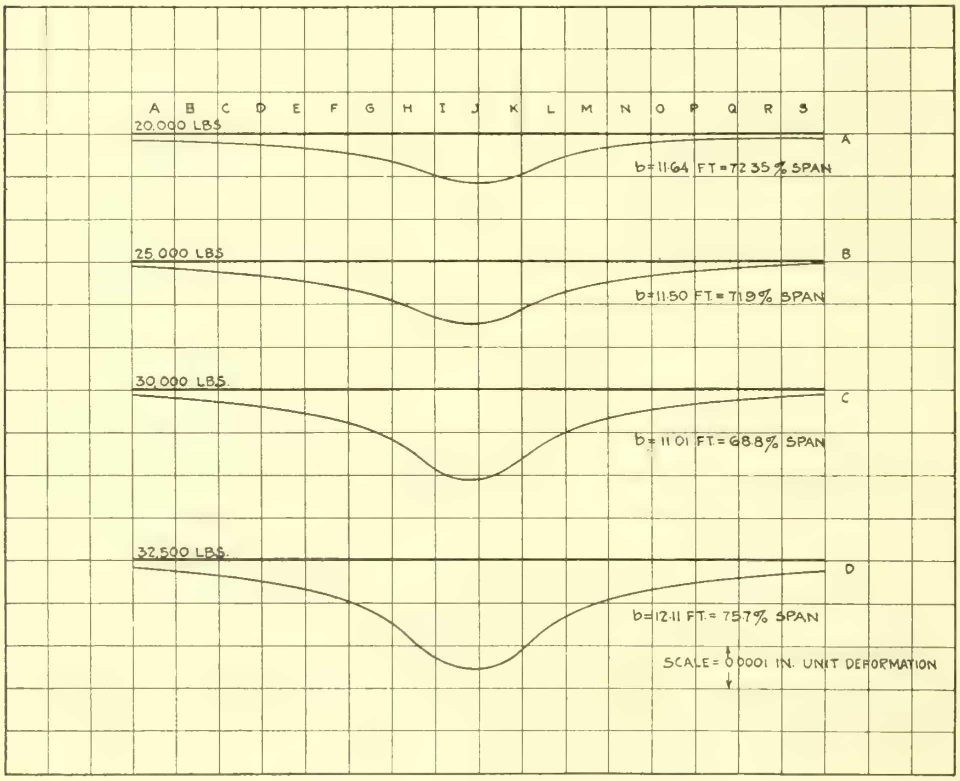
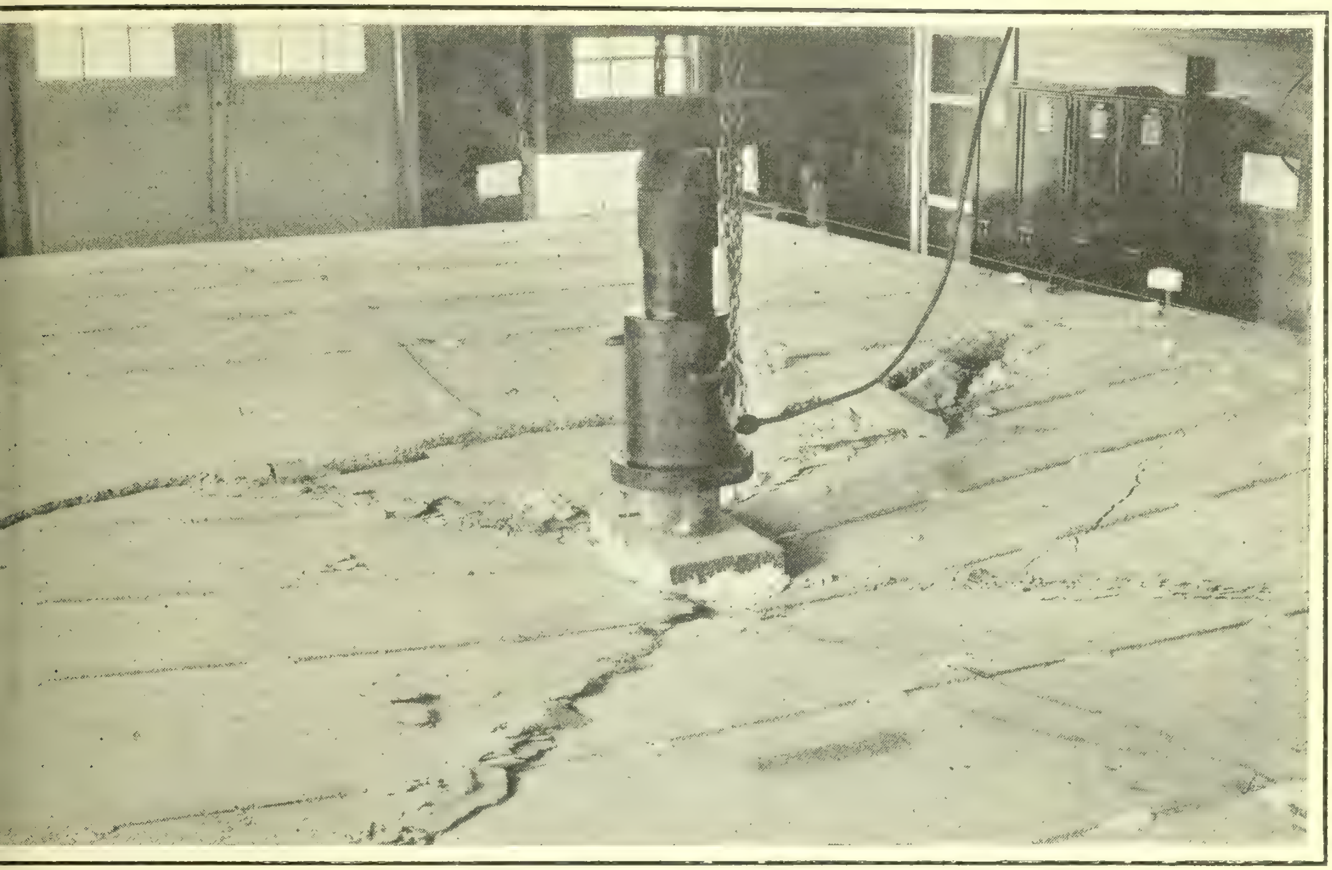


FIG. 2.—SHOWING HOW THE STRESS VARIES IN THE SLAB.

Typical deformation curves in the concrete at th center line midway between the supports are show in figure 2. In this particular slab the total widt was 32 feet and the span was 16 feet, or the width wa equal to twice the span. The features to be notice about these curves are (*a*) the large ordinate unde the load; (*b*) the gradual decrease in deformatio to practically zero at the sides. A number of slab have been tested with a central load and havin widths equal to twice their span lengths, and th table on page 3 gives dat on the slabs tested at th Bureau of Public Road during the past five years

SLABS HAVING WIDTHS LESS THAN TWICE THEIR SPAN.

The foregoing discussio treats of slabs havin widths equal to twice th span length, in which cas the sides of the slabs ar not stressed appreciabl When the width is les than this, however, stres does reach the sides, an the narrower the slab the more are the sides pu under stress as seen i figure 3. It will be recognized that the width of th slab plays an importan part in influencing the effective width. The amoun of this influence has bee quite fully investigated by a number of slab tests in which the width of the specimen has been decreased after each load application, the sides of th slab having been split off by means of plugs an feathers. It has been possible to obtain the follow



A 16′ × 32′ SLAB SPECIMEN AFTER FAILURE.

ng values for effective width from these investiga- ions.

Table I (plotted in figure 4).

TOTAL WIDTH ÷ SPAN.	EFFECTIVE WIDTH ÷ SPAN.
0.1	0.1
0.2	0.2
0.3	0.28
0.4	0.37
0.5	0.44
0.6	0.50
0.7	0.55
0.8	0.58
0.9	0.62
1.0	0.65
1.1	0.67
1.2	0.68
1.3	0.70
1.4	0.71
1.5	0.72
1.6	0.72
1.7	0.72
1.8	0.72
1.9	0.72
2.0	0.72

The above values may be used for spans up to 16 eet at least, and probably for longer spans.

TWO LOADS ON THE SLAB (*Fig. 5*).

When the span is such that a single axle load will ontrol the maximum bending moment, the slab is ubjected to two wheel concentrations, and the most dangerous condition exists when these wheels are midway between the supports. In order to investigate this condition, tests were made on slabs with two loads spaced 5 feet apart on the center line of the slab. Note the fact that directly under the load the deformations are greatest, and are even slightly greater than the deformation at the center of the slab. This stress distribution does not hold, however, for every thickness of slab, for a few of the tests show the deformation to be greatest at the center. The effective widths of slabs loaded in this way may, in general, be assumed as equal to the effective width due to a single load plus 4 feet.

ECCENTRIC LOADS.

When a heavy load traverses a slab bridge it may not remain at the center line but may travel over the bridge near one side. Again there are often occasions when a heavy traction engine will stop at the side of a bridge spanning a stream, in order to replenish its supply of water. On such occasions heavy load concentrations are supported on the side of the bridge as eccentric loads, and this is a much more severe condition than that of the centrally applied load.

For the investigation of this case a slab specimen 16 feet in span, 32 feet in width and 13 inches effective depth was made up. The original width was decreased after each test by cutting strips off of one side. The loads applied in the center of the original 32-foot width became an eccentric load as the side of the slab was gradually removed. Referring to figure 6, the strips *ij*, *hi*, *gh*, *fg*, *ab*, *bc*, *cd*, and *de*, were split off in the order named. The load was always applied to the same spot, and thus its eccentricity varied as the slab width was decreased. Without going into the details of the test, the results are shown in the curve in figure 6. The dash line curve is merely a duplication of that in figure 4, and applies to wide slabs under a central load. The solid curve is based on the tests of the eccentrically loaded slab. Note that about 10 feet were spilt off the sides of the slab before the effective width began to differ from that of the centrally loaded slab. The load was then 6 feet from the side of the slab, and when its distance to the side became less than this, the effective width became much less than that of the same slab centrally loaded. This is shown by the deviation of the solid line from the dash line. The dotted line is plotted to represent the effective width of an eccentrically loaded slab with values for this effective width assumed to be equal to $\frac{b_c}{2}+D$

Where b_c = the effective width of the slab under central load. D = distance of load to nearest side of slab.

This curve follows the curve of test results very closely and it may be quite safely stated as a general proposition that when a slab is eccentrically loaded, the effective width to be used in design may be calculated in the following manner:

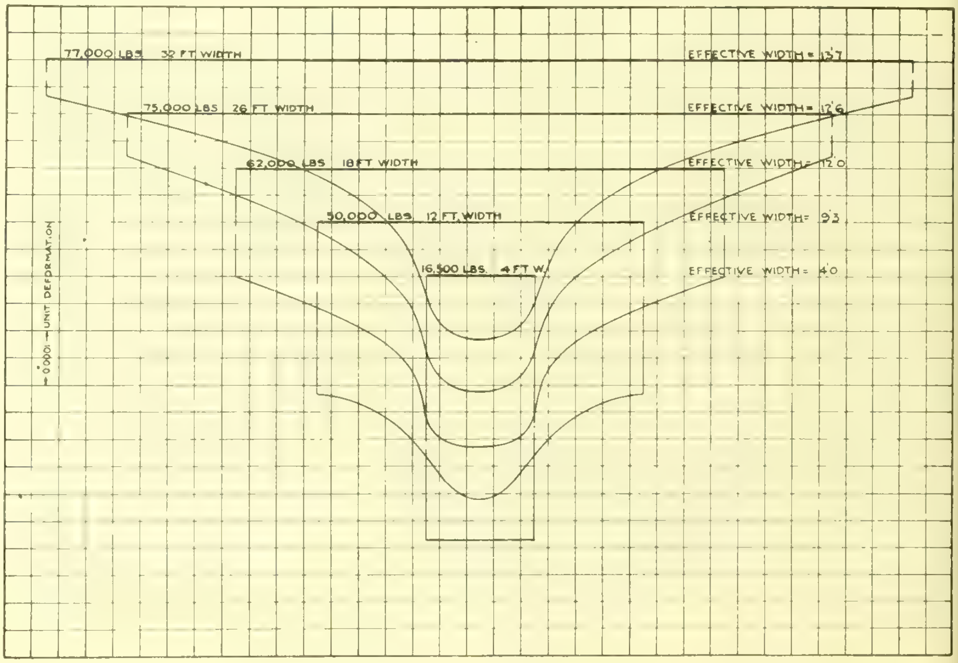


FIG. 3.—HOW THE WIDTH OF SLAB AFFECTS THE STRESS DISTRIBUTION.

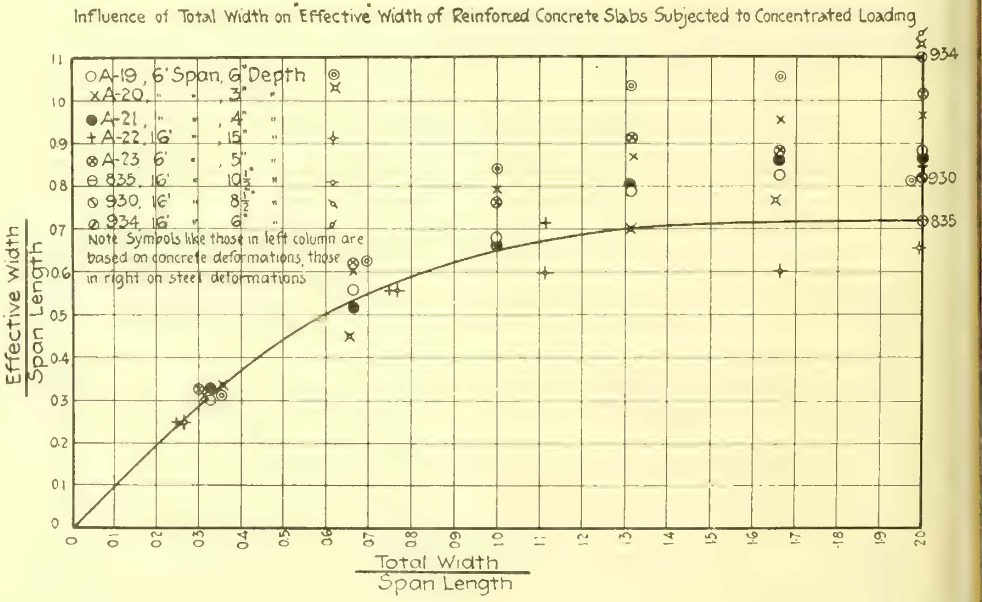


FIG. 4.

(1) When the distance of the load from the nearest side is more than half of the effective width of the centrally loaded slab (Table No. 1) use the effective width for central loads.

(2) When the distance of the load from the side of the slab is less than half the effective width under central loads (Table 1) the effective width is to be taken equal to $\frac{b_c}{2}+D$. In order to make a slab bridge eccentrically loaded equal in strength to one centrally loaded, it will be necessary to supply extra strength at the sides by means of a parapet wall, and the following procedure for the design will give safe results.

(1) Use the formulas for narrow rectangular beams substituting for the breadth b the value obtained from Table 1, (2) determine the loss in effective width due to the assumed eccentricity of the load, (3) supply the deficiency by designing the curb of the parapet to provide a resisting moment equal to that of the slab width lost due to eccentricity. Allowance will have to be made, however, for the stiffness of the section under the parapet. An unfinished test thus far indicates that this method of design is safe at least.

To illustrate the above method. Assume the slab 16 feet in span length and 20 feet in width, designed to carry a concentrated load to be applied 3 feet from one edge, then the

$$\frac{\text{Total width}}{\text{span}} = \frac{20}{16} = 1.25.$$

From the table for central concentrated loading (Table 1), the effective width $= 0.69 \times 16' = 11.04$ feet $= b_c$. Consider the load to be carried by a width of 11.04 feet, use the ordinary formulas for rectangular beam design, and determine the effective depth of the slab and the area of the steel required. Next determine, by the relation indicated above, the effective width with the load placed 3 feet from the side.

$b_e = \frac{11.04}{2} + 3$ feet $= 8.52$ feet = effective width for eccentric load.

The difference between the values of b_c and b_e is $11.04 - 8.52 = 2.52$ feet. The curb of the parapet should, therefore, be designed so that it will have a resisting moment equal to that of a slab of width 2.52 feet.

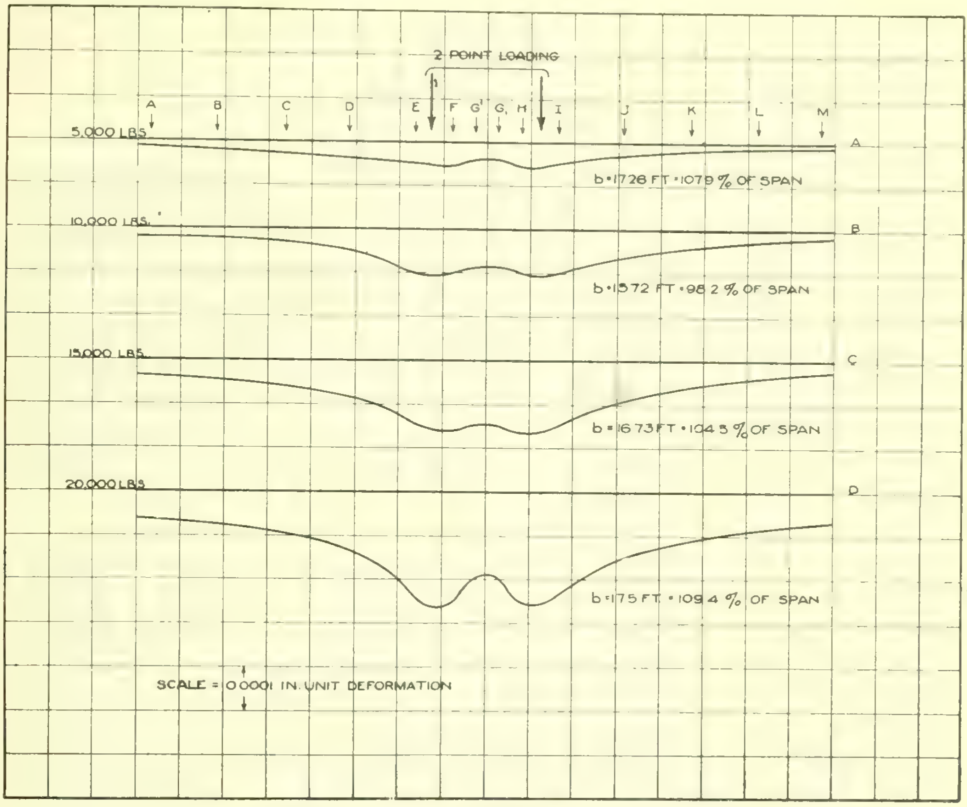
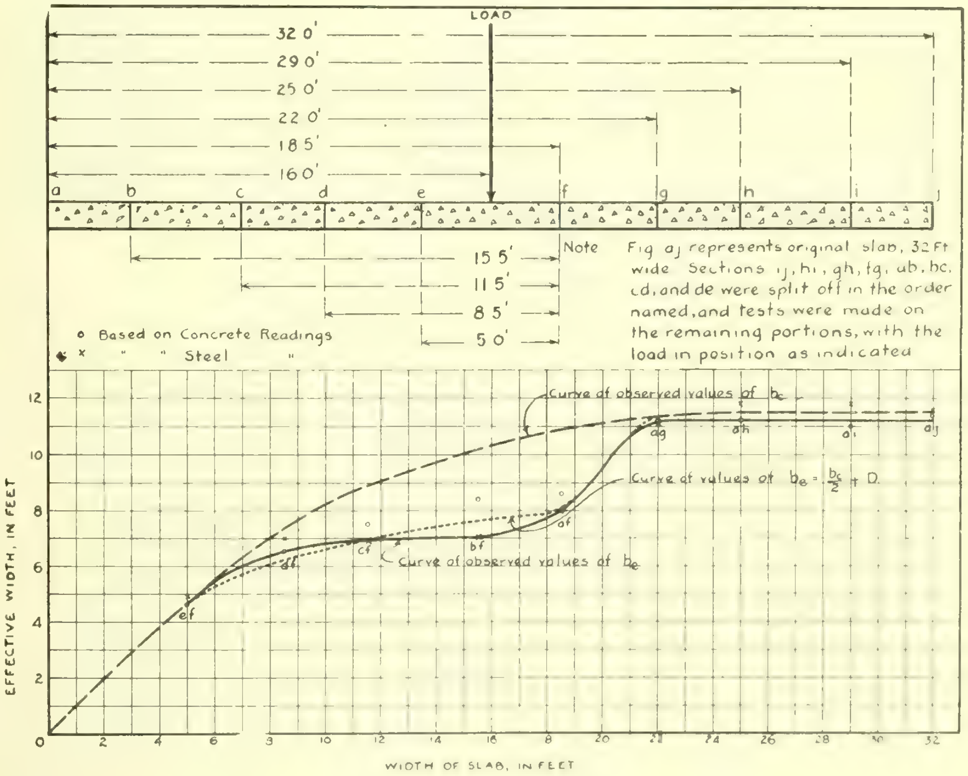


FIG. 5.—STRESS DISTRIBUTION UNDER TWO POINT LOADING.



Note Fig aj represents original slab, 32 Ft wide. Sections ij, hi, gh, fg, ab, bc, cd, and de were split off in the order named, and tests were made on the remaining portions, with the load in position as indicated

CURVE SHOWING

EFFECTIVE WIDTH vs WIDTH OF SLAB

FIG. 6.

Although there are several other conditions which may arise in the investigation of bridge slabs, the few above considered are most important, as they generally control the design.

UTILIZING LOCAL STONE

By GEORGE E. LADD, Bureau of Public Roads

ONE of the results of war-time activities during the current year has been the great interest in the utilization of local stone in road work. In some parts of the country rail transportation of broken stone in any considerable quantity is very slow and granted so reluctantly by the Railroad Administration that officials responsible for the maintenance and reconstruction of highways can not rely any longer on former sources of supply. Consequently there is a quite general return to the use of small crushing plants for producing road material locally.

From the viewpoint of a quarryman engaged in producing crushed stone there are two distinct types of crusher installations. One of these is for large-scale production and is operated continuously, if practicable, in order to keep the unit cost of the product as low as possible. The other is a small type, producing rock for local purposes and often the rock for but one stretch of highway. The methods of conducting the blasting and conveying the material in large quarries usually differ from those in the plants which it is best to employ in small operations. The failure to understand the essential differences between large-scale and small-scale operations is responsible for much of the unnecessary high cost of utilizing local materials with portable plants. Furthermore the conditions favorable for the production of crushed stone exclusively may be unfavorable for turning out dimension stone. For example, a multiplicity of joint planes is an advantage in producing rock for crushers and may render the ledge of little or no value for other purposes.

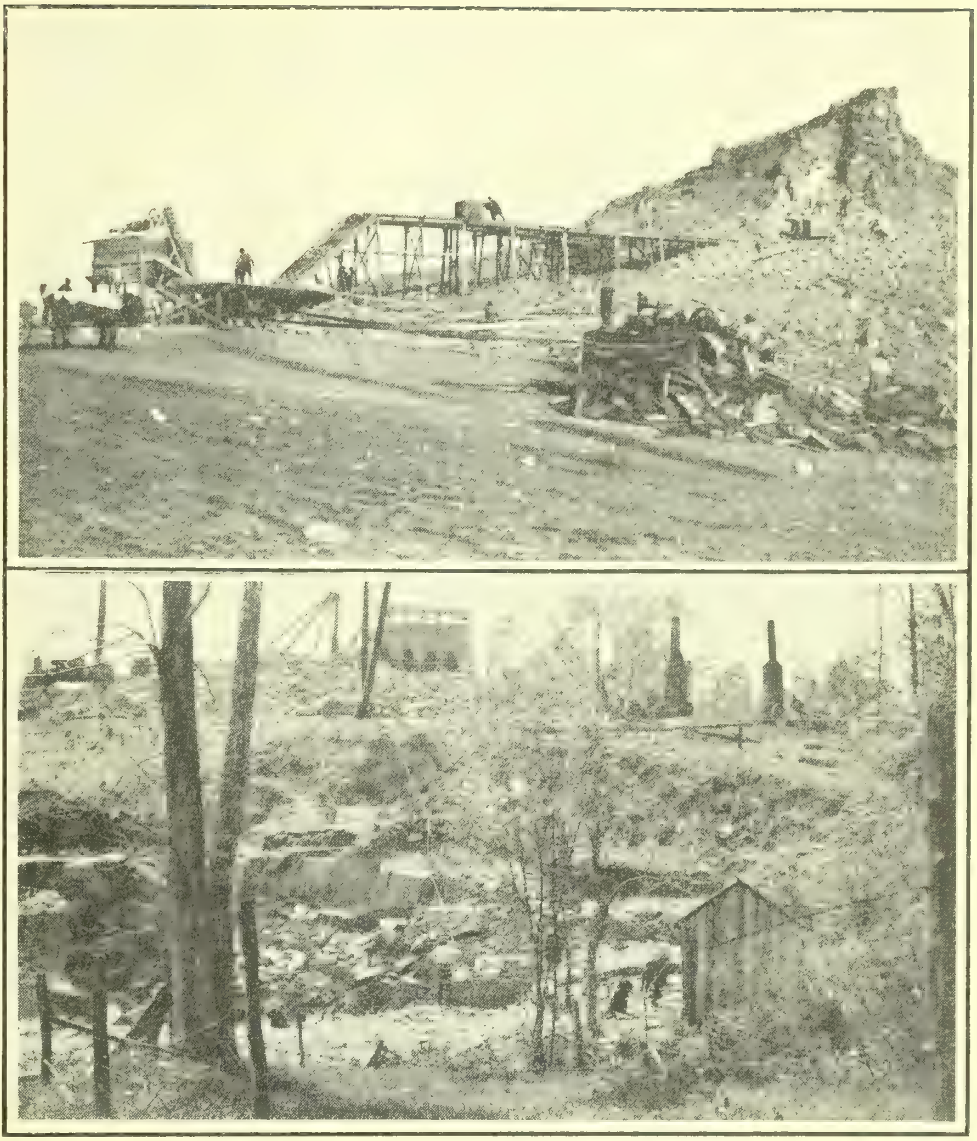
There are two general classes of quarries used in small-scale work. The first is the temporary quarry which will probably be abandoned after it furnishes the material for which it is opened, and the second class is the small quarry which may be operated intermittently to meet later demands for crushed stone. In the latter class more preliminary work is warranted than in the former. It may be desirable in such cases to avoid a thick overburden on the rock, to spend more money for drainage, and to install a more expensive plant than where there is no probability that stone will be taken from the quarry after the original working of it. For a single operation it may even be desirable to employ stiff uphill haulage, which is undesirable if the quarry is to furnish stone from time to time in future operations.

In studying local stone, where any question concerning its availability for road work arises, samples should be sent to the State highway commission or to the Bureau of Public Roads at Washington. During the period of the war it will be necessary in some sections to use stone which is not of the most desirable quality, but great care should be exercised to develop those quarries which will supply the best material it is practicable to obtain without railroad transportation. Fortunately in a number of States a large amount of information has been collected regarding the location and quality of stone which can be employed for highway construction, but the development of the commercial crushed stone industry has tended to diminish the value of such information during ordinary times, and the existence of it may not be generally known. Most cities have one or more well-informed amateur geological enthusiasts whose assistance in preparing a list of the available local sources of supply will prove useful, even though they have no knowledge of the qualities which a stone must possess to be fitted for road work.

THE QUARRY SITE.

The selection of the quarry site, even for small operations, may involve the weighing of a number of factors. It is of course desirable to reduce the amount of overburden which must be stripped, but this factor, upon which much stress is frequently laid by authors discussing large-scale quarrying, may actually be of relative unimportance in temporary work in connection with roadbuilding. It is desirable to obtain rock which is undecomposed, and the extent of the fissures and the filling of fissures by clay and detritus may be determining factors in selecting the ledge. The length of haul and the grades over which the hauling must be done, the possible location of the crushing plant, the delivery of the quarry rock to the crusher platform, and the delivery of the crushed stone to the wagons or trucks must all be considered. Drainage is often an important factor. The quarry floor, the mechanical plant and the roadways must be kept dry.

If sedimentary rock is to be used and the beds are not horizontal, the site should be selected as a rule so that the bedding planes will dip either to the right or to the left as they appear in the face of the quarry. In order to attain this end it is necessary to determine the strike and dip of the bedding planes. The strike is the line made by the inter-



TOP: ECONOMICAL ARRANGEMENT OF CRUSHER PLANT. STONE RUNS TO CRUSHER BY GRAVITY. BOTTOM: EXPENSIVE WAY OF GETTING ROCK TO CRUSHER.

section of the plane of a dipping bed with a horizontal plane, and is recorded by giving its angular direction with respect to a north and south line. The dip is the angle which the dipping plane makes with a horizontal plane intersecting it and is measured at right angles to the strike. The dip and strike can not be ascertained from a single cross section of the strata. At least enough of the surfaces of the bedding planes must be seen to show the average position of the beds in the rock to be quarried.

In ledges of granite and metamorphic rock, structural planes resembling bedding planes may occur. The quarry face should be opened in such cases so that these planes dip to the right or to the left in the face. This reduces the amount of work to be done against gravity. If a face can not be opened in this way, it is better to open the quarry with the main structural planes dipping into the face rather than away from it. Where bedded rocks have a gentle dip, and the quarry face is opened so that operations proceed toward this dip, there is danger of following a bedding plane down with the dip and producing a floor sloping toward the face, which will form a pocket for the accumulation water and make it necessary to haul stone upgrade to the crusher.

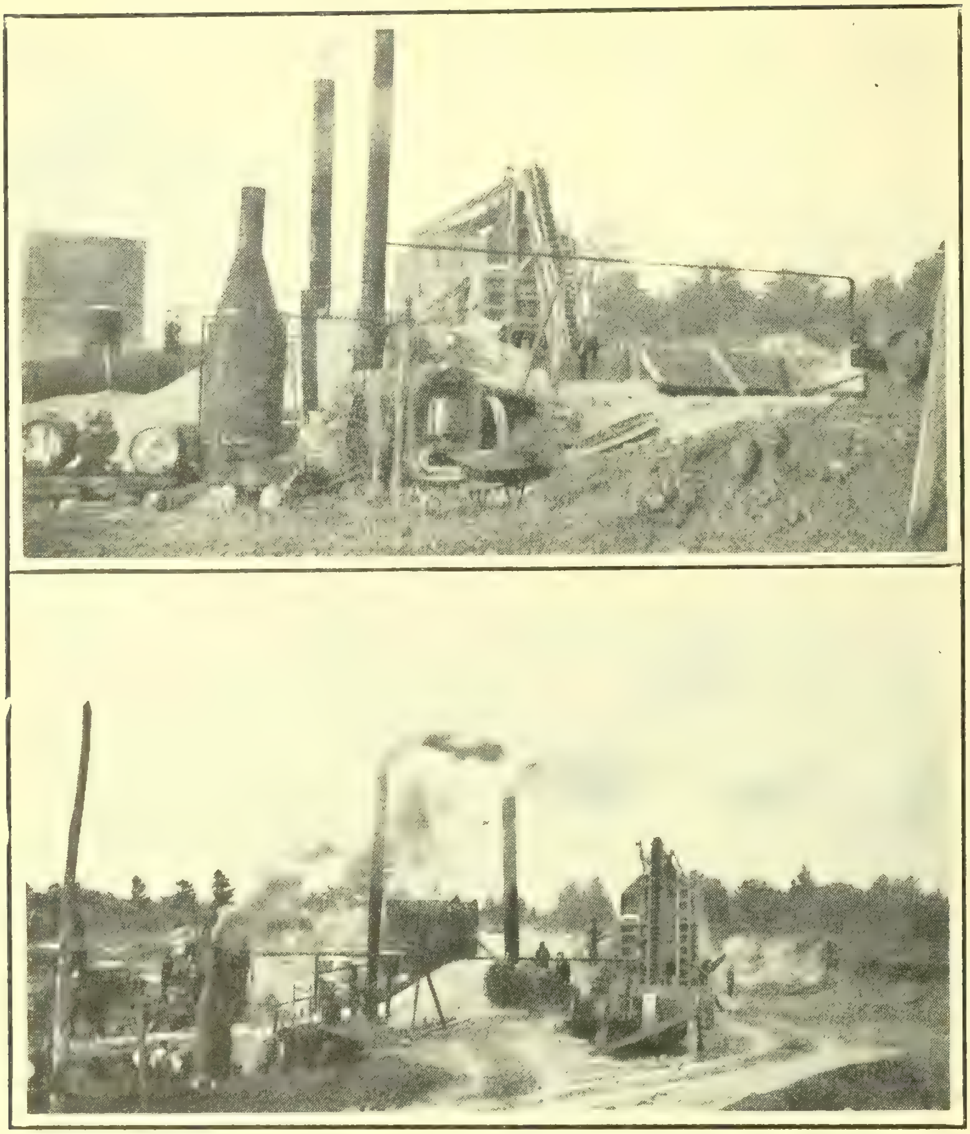
Stripping the quarry is usually done from time to time as the quarrying proceeds, in the case of small work.

QUARRY EQUIPMENT.

For small quarrying operations, the steam or air drill mounted on a tripod is required for the deeper holes for blasting down the face, and a hand hammer drill for putting holes in bowlders or for shallow work in opening the quarry. The hand drill can be used in the softer rocks for the blasting of the face if it is benched to 12-foot faces, but it is unwise to depend upon it for such work if a tripod drill can be obtained. Many plants have excess boiler capacity which enables the drill to be operated without a special boiler plant, but if the crushing equipment is some distance from the quarry face it may be advisable to install a boiler for the drills exclusively.

Light railways for handling stone from the quarry to the crusher have not often been used in temporary plants, but where labor and horses are scarce, and light railway equipment can be obtained at a reasonable expense, it may prove economical. Conveyors are occasionally employed in gravel pits. As a rule the stone is handled in dump carts.

The crushing plant on these small temporary operations is generally rated as requiring about 15 to 30 horsepower, which is enough to furnish from 6 to 30 tons of hard, tough crushed stone per hour. Belt drives are desirable for crushing, screening and conveying machinery, for a belt will slip if a sudden overload occurs and the danger of breakage is materially reduced in this way. It is customary to estimate that at least 1 horsepower must be provided



TOP: PORTABLE CRUSHING, SCREENING, AND DRYING PLANT. TEAMS ARE DRIVEN ACROSS PLATFORM AND RETURN. BOTTOM: SHOWING ROAD TO AND FROM CRUSHER PLATFORM. THIS IS A MORE ECONOMICAL ARRANGEMENT THAN WHERE THEY HAVE TO TURN ON THE PLATFORM.

per ton of product per hour for a small crusher, and about one-half horsepower for elevating and screening, where jaw crushers are used, and 25 to 50 per cent more for a gyratory crusher. The boiler horsepower must be in excess of this. A 3½-inch tripod drill requires 8 to 10 boiler horsepower.

Elevators to raise the crushed stone from the crusher to the screen are generally necessary. The foremen should be instructed to keep the pit at the foot of the elevator cleaned out. In some cases a conveyor can be used to advantage to carry quarry rock to the crusher. The screens in small portable plants are generally placed on top of the bins, which hold from 12 to 50 tons of screened stone, and are equipped to discharge their contents by gravity. Where crushed gravel is produced, it is desirable to screen it so that only the oversize material goes to the crusher. For this purpose a screen is usually set up near the crusher in such a position that the oversize is delivered to the crusher as directly as possible, and the sized material is delivered either to a stock pile or to the bins receiving the crusher product, depending on the local requirements.

In war times it is specially desirable to reduce the amount of labor required about the quarrying and crushing plant. An able-bodied man should not be used if machinery to take his place can be obtained at reasonable expense. For example the crushing plant can sometimes be located so that the stone is fed to it from the quarry by gravity. It is desirable to place the crushing plant as near the quarry face as practicable, and yet avoid damage by the blasting operations. It is desirable to drive the rock carts across the crusher platform rather than to turn on it. A crusher having a large jaw reduces the number of bowlders which must be broken up. Good foundation should be provided wherever necessary, and all shafting must be kept aligned and lubricated. Machinery o this character receives such severe usage that it is advisable to give more than the usual attention to its care, in order to avoid shutdowns for repairs which proper maintenance would avoid. Such shutdowns often result in the idleness of a large part of the construction force, and where the work is already lagging behind the desired rate of progress this may be a serious matter.

QUARRY OPERATIONS.

The operations which are most likely to cause unnecessary expense in quarrying are: Drilling; the proper spacing and proper location of holes; blasting. Different classes of rock resist explosives so differently, and there is such a wide variety of working conditions at different quarry sites where the kind of rock is the same, that even experienced

TOP: TEMPORARY QUARRY WITH TWO PORTABLE CRUSHING AND SCREENING PLANTS. DOWN GRADE TO HIGHWAY JUST TO LEFT OF QUARRY. BOTTOM: DELIVERING ROCK FROM TEMPORARY QUARRY NEARBY TO PORTABLE CRUSHING AND SCREENING PLANT FOR ROAD IN BACKGROUND.

quarrymen must experiment at every new quarry to determine the best blasting methods.

If the surface of the rock is practically horizontal, a sunken-type quarry must be opened. It will then be necessary to hoist the material out of the quarry or to build a sloping incline down into it to enable the material to be hauled out. In this case three or four drill holes about six feet deep are driven at an angle of 30 to 40 degrees inclosing a pyramidal mass of rock. After this has been blasted out, the pit is opened out until a face, usually curved in plan, has been obtained. Additional depth is obtained by repeating the whole process in each successive floor. While opening up the quarry in this way valuable information can be obtained concerning the best explosives to use and the proper spacing of the holes. As a rule it is best to try 40 per cent dynamite first, if the rock is limestone, and 75 per cent dynamite if it is a tough igneous rock. If the results are unsatisfactory a trial of some of each grade in each hole can be made, and the proportions of the two varied until the best results are obtained. Slow-acting explosives lift and throw rock more than quick-acting grades, which have a greater shattering effect.

If an approximately vertical face can be obtained, at which to start the quarrying operations, it is customary to sink the first row of holes back from the face a distance equal to about three-fourths of their depth. The depth of the holes in the benches is commonly 10 to 12 feet, and in a complete quarry face it may be 18 to 20 feet. The work of development is carried on until the quarry face has a slope of about 45 degrees. The overburden is then stripped off and regular quarrying operations begun. The first holes are in a row 6 to 8 feet back from the face, 6 to 7 feet apart, and sunk nearly or quite to the floor. If there is a seam or bedding plane at the floor, the holes may be stopped 5 or 6 inches above it, for the blasting will break the rock to the seam. The next row of holes may be sunk at a distance back from the face equal to three-fourths of their depth.

The proper spacing of drill holes in the regular quarrying operations depends upon the hardness and toughness of the rock, the number and arrangement of the joint planes and seams, the depth of the drill holes, the kind and amount of explosive used, and its vertical distribution in the holes. Experiments must be made until an arrangement is found which will not only tear down the face but will break the rock most completely for the crusher.

The choice of explosives, unless an expert powderman can be consulted, should only be made after securing the advice of the powder company supplying the explosive. These companies also furnish complete instructions for using dynamite, which should be thoroughly taught to the man in charge of the quarrying operations.

Small quarrying and crushing operations are always expensive, per cubic yard of output, in comparison with large-scale operations. It is all the more desirable, therefore, to carry on the work so that these costs will be as low as possible, which can only be done by requiring the foreman to keep a detailed record of his expenses and the output of the plant. These records should show his progress in reducing the drilling and explosives needed to blast out the rock, the labor required in delivering it to the crusher, and the expenses of the crushing. Constant endeavor should be made to encourage foremen to seek methods of greater efficiency in the work under them.

MAINTAINING GOOD ROADS.

It is axiomatic with householders that "keeping up the house is the truest economy." And so most of us watch for signs of decay about our premises, and we putty and paint and repair, to guard against the heavy expenses that would be the certain penalty of serious neglect.

But when it comes to municipal housekeeping what is our practice? Usually long periods of positively wanton neglect. This is especially true of our roads, which are an important part of our municipal premises.

We build our macadam streets, bolster them up with a good foundation, surface them with the best material at hand, roll them, view the finished job with satisfaction and then, like a slovenly home owner, pay no further attention to them until they have fallen into such a disreputable state that the steam roller must come with its plows, tear them to pieces and begin a work of complete reconstruction.

Practically all of the nations of Europe have long ago learned the economy of road maintenance. As you travel over the beautiful, hard macadam roads of France you observe, at intervals, small piles of broken stone and gravel. And for every dozen miles of road there is a road patrol with his one-horse cart, who labors incessantly at filling up the little depressions, ruts and holes, with his ever ready supply of good material. Once filled, the damaged spot is wet down thoroughly and tamped, and the road becomes again an integral whole. The thrifty householders of France have thus carried into the housekeeping of their municipalities and provinces the economics which they practice about their own hearth stones.

—Dubuque, Ia., Times-Journal.

BUSINESS MEN WORK ROADS.

Twenty-five business men of Bluffton, Ohio, put in a day working on the roads leading out from that town, in order to get them in better shape. More than 25 miles in all were repaired.

CONSIDER IOWA'S ROADS.

At the summer conference of the commercial secretaries of Iowa, held in August, a full day was spent discussing Iowa's roads, how they could be improved, plans for future development and an educational campaign throughout the State in regard to them.

URGE ROAD WORK AS WAR MEASURE.

The Ohio State Automobile Association set under way a campaign for the dragging and scraping of dirt roads in that State this fall, with the idea that otherwise unimproved roads may be used as late as possible into the season of bad weather. It is urged that it is the duty of township and other road authorities to take steps for this work, that the big crops which have been raised may be moved to receiving centers and railroads and not lie on the farms. Drainage of these roads is especially emphasized.

BAD ROAD LOSES MAIL SERVICE.

Near Decatur, Ill., a part of one of the rural mail routes has been cut off and the service transferred because of the bad condition of the road, which was not repaired after 60 days' notice had been given. Several families thus lose their mail delivery.

FOR TENNESSEE HIGHWAYS.

The Tennessee State Highway Committee held a meeting in August at which State and Government funds were allotted for road construction in Anderson, Hawkins, Unicoi, Sullivan, Cocke, Campbell, Madison, and Maury Counties. About $10,000 were appropriated for each county. The Maury County road will be along the Jackson Highway. The route of the Bristol-Memphis Highway west from Nashville was decided in favor of the Charlotte Pike or Dogorock route.

TO PROMOTE MOTOR TRUCK EXPRESS.

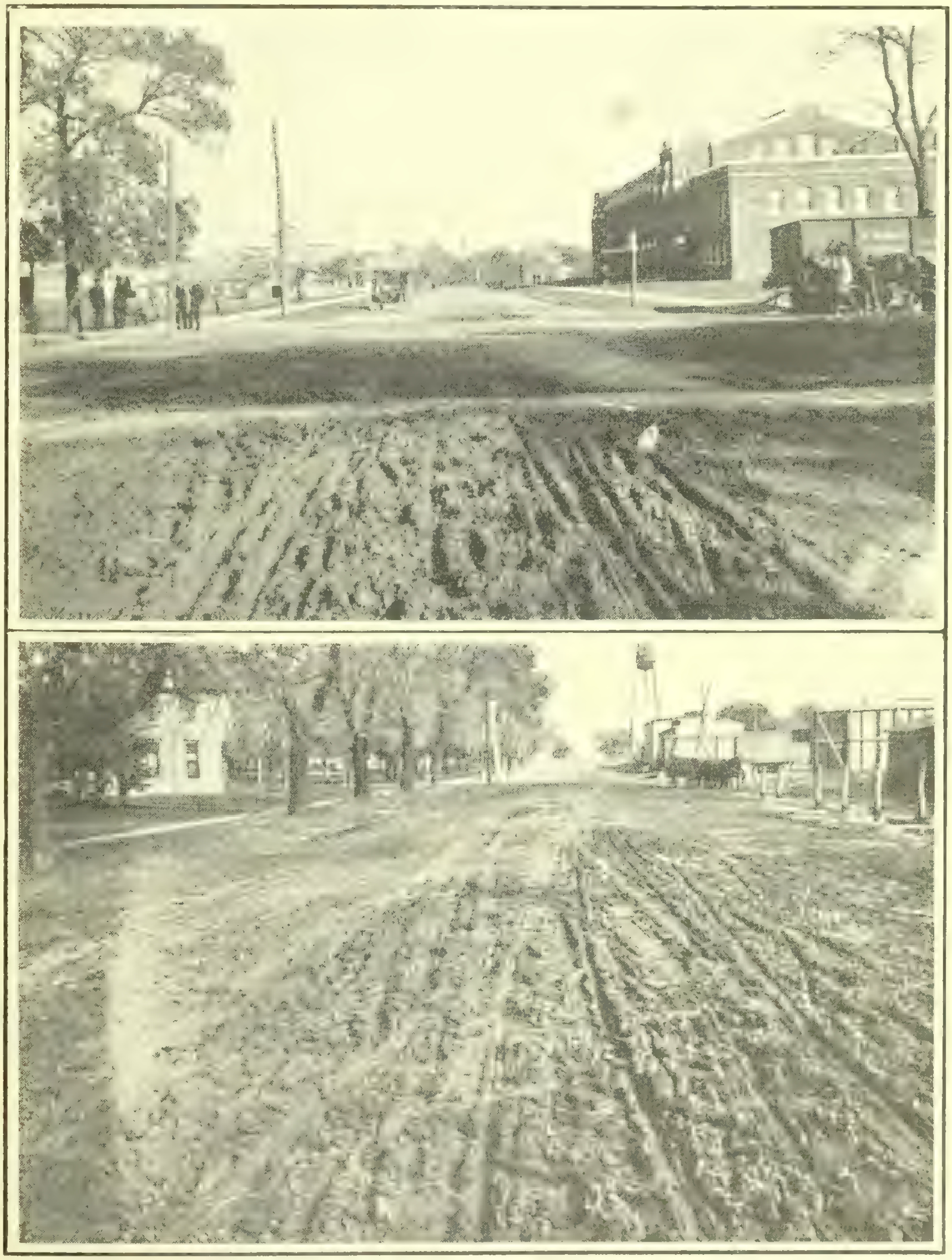
The Highways Transport Committe of the New York State Council of Defense will carry on a campaign in every county in the State to promote motor express lines. In addition to establishing rural motor lines the chief endeavor will be to start return load bureaus and to secure the removal of snow from roads so as to permit truck transportation the year round.

Highway Commissioner Duffey told the committee at a recent meeting that State highways had stood the severe test of the movement of Government motor trucks with excellent results, save where the trucks were used last spring on the older sections before the frost was out of the ground.

MAINTAINING EARTH ROADS WITH OIL.

By THOS. H. MACDONALD.

THE State of Iowa has learned by experience that the use of certain asphaltic road oils which produce a mat when applied to an earth road gives good service for a limited time under moderate traffic.


STREETS IN SAME, IOWA. TOP: OILED INTERSECTION SHOWING UNOILED APPROACH. BOTTOM JUNCTION OF OILED AND UNOILED SECTIONS.

With the prices on all types of paving surfaces almost at the prohibitive point, with labor for new construction and for dragging and blade grader maintenance next to impossible to secure, and with a considerable mileage of important roads which have been maintained for several years past by oiling and which must continue to receive such treatment or go entirely to pieces, it would seem that oiling certain Iowa roads should receive attention as a war-time economy measure. On some limited sections of highway it would seem reasonable to class road oiling as a war-time necessity.

The dirt road on which oil has formed a good mat will withstand much more traffic for a considerable time with very little maintenance and with more freedom from dust and mud nuisance than the unoiled earth road even with a considerable maintenance expense. While the traffic that these oiled dirt roads carry is heavy for Iowa, it is not heavy for more densely peopled sections of the country where heavy motor trucks are used. What we mean by heavy traffic in Iowa is a very large number of light automobiles and light trucks, and for such traffic the mat produced by the suitable grade of road oil on a well-prepared dirt road affords a sufficiently good wearing surface, though we have found it an extremely expensive one to maintain.

While the application of good road oil to properly graded and drained earth roads maintains them in a serviceable condition, very poor results have been obtained with the use of some of the cheaper oils on gravel surfaces. In come cases the oil has acted apparently as a lubricant to the pebbles forming the gravel and has helped to destroy rather than to increase the road bond. During the period of the war paving is out of the question as a remedy for road conditions in Iowa, and will soon be stopped entirely. We will necessarily fall back upon those systems of maintenance which will retain our present roads in a serviceable condition as long as possible, even at an excessive cost. Hence, we feel that our experience with the use of asphaltic road oils justifies us in employing them in our maintenance work. We can not maintain our roads in the condition needed for the traffic they must carry in some places without such oil.

It is undoubtedly true that oil has been used on earth roads in many cases when it should not have been employed, and the same criticism can be made on every form of maintenance and road paving. However, our experience shows that in the allocation of road oil for street and highway purposes the distribution of the material should not be based solely on the character of the roads to which it is to be applied. Consideration should be given to the service the roads are called upon to render. There are surfaced roads in sections of Iowa which do not carry so much or so important traffic as the earth roads in other sections carry, and there are surfaced roads in other States which do not begin to render the important service to the community that earth roads are called upon to render in Iowa.

The situation that we are facing in Iowa at this time is an unusual one. We do not believe in the general extensive use of road oil on earth roads. We have always refused to approve of this practice on the ground that the results were not comparable with the expenditures, but under present conditions we find ourselves attempting to carry an ever-increasing amount of traffic over roads which must be used without more surfacing. It is not so much a matter of cost as of the actual impossibility of securing contractors willing to take the work under any conditions. We must maintain our principal roads with the absolute minimum of labor, even though the cost of doing so is excessive, and the use of oil of good quality assists in attaining this end. Therefore, it seems logical that road oil which is available for country highways should be desirable on the basis of the service to be rendered by the roads which it is proposed to oil rather than by the actual character of the roads surfaced now.

TOLL ROAD PURCHASED BY STATE.

Arrangements have been made for the purchase of the Lancaster, Pa.-Columbia Pike from the Lancaster and Susquehanna Turnpike Company, for $80,000, which will give to the stockholders about $400 a share for their stock. The road will soon be a free public highway.

LOUISIANA ROAD PROJECTS.

At a meeting of the police juries of Terrebonne, Lafourche, and St. Mary Parishes, La., in August, it was decided to build three roads in these Parishes which affect all mutually, and also to build the link in the Southern National Highway stretching across Assumption Parish, 3½ miles long, which will shorten the road between New Orleans and Morgan City by 10 miles. A portion of the funds for this link was raised by private subscription.

FOR $50,000,000 ROAD FUND.

An amendment to the Pennsylvania constitution will be voted on at the November election this year to authorize the creation of a State debt of $50,000,000 for the building and improvement of highways. Five years ago a similar proposition was defeated. It is believed that now the voters of the State see the question in a different light. Advocates of the proposition hold that the great importance motor truck transportation has developed has made clearer the necessity for better roads in Pennsylvania.

MISLEADING MILE POSTS.

A movement has been started in Hamilton County, Tenn., to abolish the system of advertising mile posts which exists along the public roads in that county. A very complete case has been made out against the system. It is shown that these posts are not reliable, that in the same locality will be found signs differing much as to distances, and that much confusion and misunderstanding is brought about by them.

The mile posts are erected on the county's right of way, and it is believed that jurisdiction over them is with the highway commission. Some legislation may be necessary to effect desired results. It is proposed to have every highway properly measured by the county engineer and mile posts erected by the commission at the public expense.

TESTS OF AUTOMOBILE NUMBER TAGS

By JAS. P. NASH, Testing Engineer, Texas State Highway Department.

TEXAS, being one of the four States of the Union using the permanent number tag for motor vehicles, the State highway commission considered it good business to have sample plates from the various bidders tested before awarding the contract for additional numbers. The tags are permanent in the sense that they do not change every year, but remain with the car as long as the latter is used on the public highways. The law provides that the motor vehicle shall be provided with a seal, which alone is changed each year. So that purchasing the tags it was desired to procure a number plate that would look well and at the same time outlast the average life of an automobile, which was considered at between three and five years.

Three destructive influences were considered, first the drying action of the sun on the enamel, second, the action of salt air or water on the tags, and last the impact of sand and stones and the wearing action of loose parts tending to wear the enamel off. The test of the properties resisting the first destructive influences was by placing the tags in an oven for 8 hours at 100° C. These tags, which included the poorest as well as the best, were put through an abrasion test. In order to determine the relative value of this heating test, duplicate tags were run in the abrasion test without previous heating, but no difference in appearance could be detected, so it was concluded to abandon the heating test. Furthermore, it was decided that any paint that was hard and tenacious to resist the abrasion test to which the tags were put, would leave little doubt regarding its qualities resisting weathering. Upon examining a number of plates which had been in use for a year, it was noted that practically the only defects were that the paint had been scratched or worn away by some hard agent such as a keen knife used in removing mud.

The abrasion test was made by revolving the plates, bent so as to form a cylinder, with an abrasive agent of iron hexagon nuts. The plates were fastened, face inward, on two circular wooden rings 28 inches outside diameter. A short metal strip formed the joint between two plates. This formed a hollow cylinder, the tags lengthwise forming the circumference, while the width of the number, which was 4 inches, determined the height. This cylinder was placed in the brick rattler as a convenient means of revolving it, only three staves being used, however, in order to lighten the load on the pulleys. Crushed quartz sand was first tried as an abrasive agent, but this had little effect on the enamel, so one-sixteenth inch steel ball bearings were then tried, but the results were not considered decisive enough, so finally 400 grams (13 in number) of one-half inch hexagon nuts were used and the cylinder was given 1,000 revolutions in either direction.

The results of this abrasion test were very satisfactory as it showed very clearly the hardness of the paint and the tenacity with which it adhered to the metal. With some of the number plates the paint was almost completely clipped off, exposing as much as 90 per cent of the metal. The paint on even the best plates was badly scratched, but no metal was exposed except at the edge of the raised letters. There were varying degrees of wear between these two extremes. It is worthy of note that

Reports of tests of auto number plates.

Maker.	Number on plate.	Thickness of metal.	Loss in weight in 2,000 revolutions.	Rating.	Condition of plate after run.
		Inch.	*Grams.*		
No. 1	174,005	0.033	....	70	Blue background badly scratched, but metal not exposed except at corners. White letters about 50 per cent worn.
No. 2	[1]381,079	.025	0.8	65	Blue background in fair condition; metal exposed at edge of letters, but letters in good condition. Metal exposed in pin-point areas in background.
No. 2	381,079	.028	1.0	[2](60)65	Blue background badly scratched and chipped off in pin-point areas. White letters in fair condition except at edges where metal is fully exposed; about 30 per cent worn.
No. 3	734,508	.028	.6	57	Blue background chipped off wherever exposed to considerable wear. White letters in fair condition.
No. 3	734,508	.028	1.7	[2](50)55	Blue background badly worn, exposing metal over large areas. White letters in fair condition; about 30 per cent worn.
No. 2	[3]381,079	.020	3.0	55	Blue background worn between letters where abrasive agent had free contact. About 85 per cent of black worn off letters.
No. 4	LA 23,600	.028	1.1	40	Green background almost completely worn away. White letters worn away at edges and had appearance of salt and pepper.
No. 5	D 5438 K A N	.024		35	Both background and letters worn so that about 75 per cent of metal is exposed; poor condition.
No. 5	D 5438 K A N	.025	1.8	30	Background and letters worn so that about 85 per cent of metal is exposed.
No. 6	140,491 111	.042	2.1	30	Paint badly worn; about 95 per cent of paint is worn off letters and 10 per cent off background.
No. 6	140,492 111	.035	3.0	2[illegible]30	100 per cent paint worn off letters and 70 per cent off background

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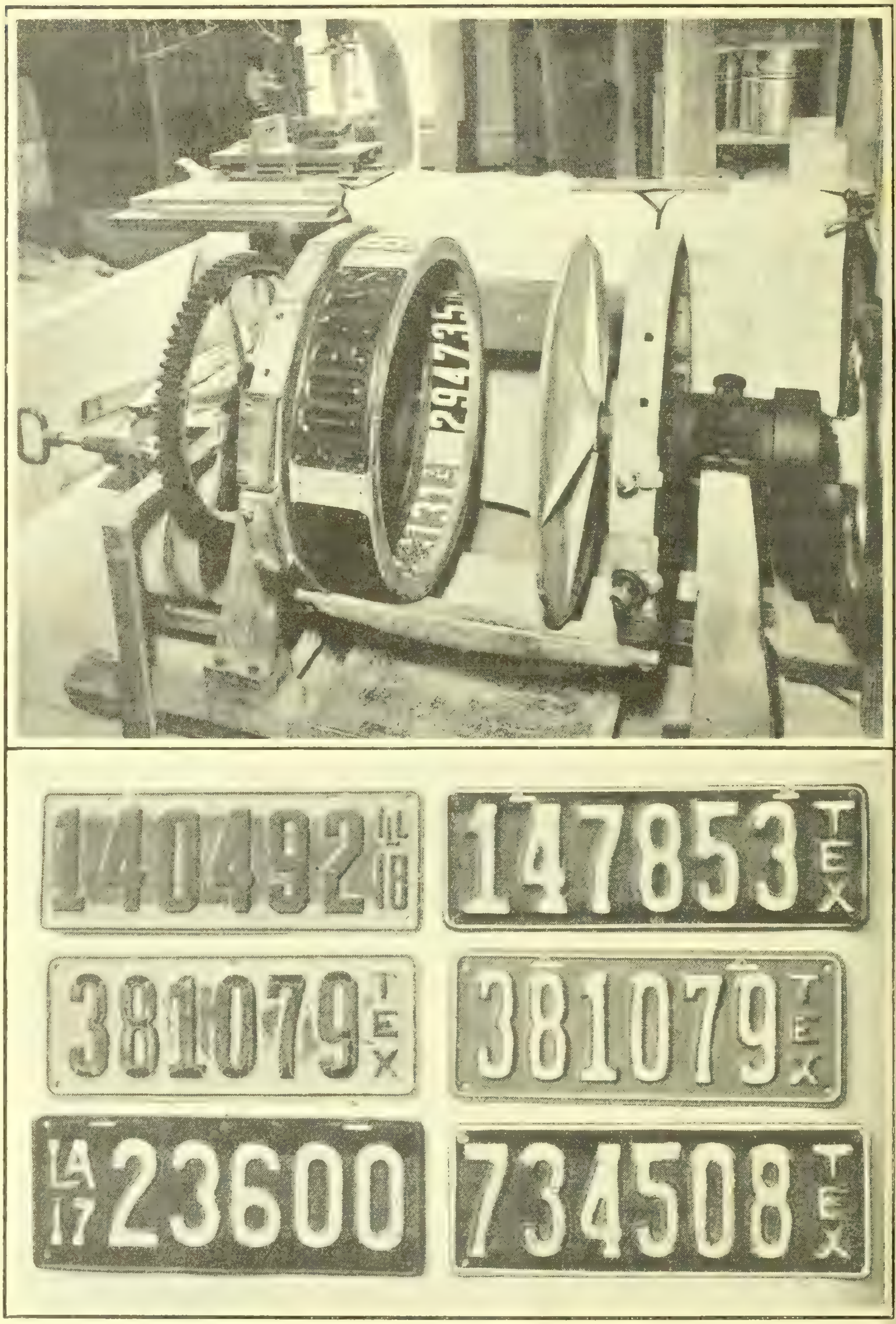
[1] No. 2 extra finish.

[2] Denotes plates were subjected to temperature of 100° C. for 8 hours and tested with sand, and ball bearings before final test with hexagon nuts. Rating arbitrarily raised 5 per cent to allow for this.

[3] No. 3.–26 gauge.



TESTING OF AUTOMOBILE NUMBER TAGS. TOP: SHOWS THE MANNER IN WHICH THE ABRASIVE TEST WAS MADE. BOTTOM: APPEARANCE OF TAGS AFTER THE TESTS.

the two highest prices bid included the best and poorest plates as shown by this test.

In order that the difference in wear could be presented to the highway commission in a forceful manner, and in a measure duplicate the weathering action of our coast country, the number plates, after the abrasion test, were subjected to a 10 per cent solution of common salt. First the tags were embedded in sand saturated with the salt water, but it was found that grains of sand rusted to the exposed metal.

To avoid this, they were removed from the sand and sprinkled with the salt water, then allowed to dry in air. A further effect, besides the rusting of the metal, was noted, and that was the paint on the backs of many of the plates became soft in spots and could be rubbed off by a slight pressure with the thumb.

The rating given the tags was a matter of judgment, arrived at by considering the plate before the run as 100 per cent perfect, and estimating the area of metal exposed by the tests, not considering the edge of the raised letters. While the actual numeric figures may be slightly in error, the relative worth of each plate is clearly brought out and the numerical rating is merely a means to an end.

The contract for 75,000 additional pairs of plates was awarded at 34 cents a pair to the concern that held the previous contract for the identical plates at 39 cents, so it was considered that a saving of at least 5 cents per pair was made by having the plates tested, besides being assured that a good quality plate was obtained.

STANDARD SIZES OF CRUSHED STONE

From the Standpoint of the Producer

By R. W. SCHERER, Secretary; Wisconsin Crushed Stone Association

THE movement to standardize commercial crushed stone sizes, inaugurated by engineers of the Bureau of Public Roads, should be and will be heartily welcomed by crusher operators. The demands as suggested by Messrs. F. H. Jackson, jr., and C. W. Mitman in their article in the June number of ‘‘Public Roads'' far from being stringent are rather too lenient. Economic plant operation is not the producers' only interest in the matter. They should be and generally are equally interested in the results from the type of construction involved and will be found willing to sacrifice economic operating to a considerable degree to gain better results.

It is difficult to see what a further survey of the screening practice and study of the nomenclature will do to clear up the situation. One could not expect to arrive at a typical set of screens by counting hoses, nor by finding a majority of installations that are alike to which the minority would conform. It s also to be regretted that the investigators found it ‘impossible to record the rate of feeding the stone nto the screen.'' That the nomenclature was in a condition of ‘‘confusion worse confounded'' needed no demonstration.

HOW PRODUCT VARIES.

To define a grade of stone all are agreed that size of screen openings through and over which the maerial passes must be stated. When these are stated he product may still vary from several causes.

First. There is an appreciable difference in the product of round and square perforations. A hole described as 2 inches square will pass a larger stone han a round one 2 inches in diameter. Square perforations are still used, though to a very small extent except in fine screens. It would be safe to confine the question to circular holes; where square perforations are retained they must be made the quivalents of circular openings.

Second. It makes a noticeable difference in the product whether screens are stationary or revolving. On a stationary screen the stone particles slide over he surface; they are held on their longest dimension. n a revolving screen the stones roll and can and do go through holes no larger than their smallest dimension. The difference in size of product is so great that the stationary screen will retain 20 to 40 per cent of material that has been passed through a revolving screen of the same size perforations. This means that the specification still retained by some engineers—naming the largest dimension as the determining one is not practicable, since stationary screens are almost unknown in the industry. If engineers knew this, they might discontinue the practice. They could guard against ‘‘slivers'' by other means.

Third: It makes a difference, of course, whether a screen of any type is overloaded or not. More often it is the large plant that has inadequate facilities for separating the sizes. Fines are carried over to the next section having larger openings. Thorough screening should be understood in designating sizes and how thorough it should be will be discussed in another paragraph.

NOMENCLATURE.

Now then, to get clearness in the matter of describing sizes. Let us describe a given product at least technically by the size of perforation which it passed through and the size of perforation that held it and let us understand thoroughly that the figures are for a round perforation, for a revolving screen, and for a screen of sufficient capacity for the plant.

And if we can best describe a given product by maximum and minimum smallest dimension, for technical purposes, why not for all purposes? Why should there be the conflicting nomenclature of numbers and more or less descriptive names. In fact, dimensions are the one description that now are universally intelligible, and it would seem that for all practical purposes, ordering stone, specifying, invoicing, and all, it is just as easy to refer to 2–1 inch stone as it is to write or talk about 23 or medium fine stone.

Probably the best established and most universal system of nomenclature is that of the granite crushers both East and West where No. 1 stone is always very nearly 2¼, 1½, and one-quarter inch and finer called No. 4. It would be very difficult to accustom the granite trade to another system of numbers, while they could be led to adopt the figures limiting the sizes.

LIMITING THE NUMBER OF GRADES.

Once we have means of describing grades of crushed stone and it would seem that with the above understanding—2–1 inch stone or any other size would mean the same thing everywhere—a further understanding could be arrived at between the producers on the one hand and road builders, engineers, and architects on the other hand as to grades that should be offered by the former and demanded by the latter.

The advantages to the crusher operators, if the number of grades can be reasonably limited, are manifest. There can be no question that there has been on the part of engineers—less of road engineers than of the specialists in structural concrete—considerable academic dogmatism about sizes for certain purposes—they have been just "finnicky." But—and this is from the quarryman's standpoint as well as the engineer's—results must be considered. It is to the quarryman's interest—and some of them can see it—to furnish just the size that will give the best results. It is incumbent on all parties interested to ascertain how much of this fastidiousness is justified and in how far the results in road or concrete are affected by a slight variation from the size demanded by some engineer whom the quarryman thinks pedantic.

THE DEMANDS OF ENGINEERING PRACTICE.

Here are some thoughts from the standpoint of the quarry operator who is interested in results, which it is hoped may illuminate the subject. On the one hand, some paving engineers, using stone in a special process of asphaltic concrete paving, have insisted on a product passed through a screen one-eighth inch larger or one-eighth inch smaller than was commercially produced. This seems to be pedantry that passes for scientific aggregating. In stone above 1 inch, one-eighth inch more or less can make no possible difference; even a quarter-inch variation seems unreasonable in 1-inch and larger stone. The demand for such variations can be eliminated.

On the other hand, quarrymen are at fault when they fail to recognize the imperative necessity for good screening. And here is where they should consider results. Stone for macadam must be distinguished from stone for concrete, and differently prepared. It makes no difference what the hardship on the quarrymen may be, results to a certain extent justify the sacrifice.

The distinction can be simply stated in this way: In macadam stone there must be a large percentage of voids, while in concrete stone the percentage must be as low as possible. To elucidate, no road builder can bind a crusher-run stone. Fines, when present in coarse stone, close the interstices and prevent the entrance of the binder even when that binder is hot tar. How much more must these fines prevent the entrance of stone screenings in water-bound macadam. In penetration macadam, road builders have had to discontinue the practice of dumping loads of the top course stone on the base, because as the load is spread with shovels the "fines" remain on the spot. The stone "mats;" the binder, instead of covering each stone, spatters on the mat; the binder does not anchor in the body of the course, and a bald spot results. A large percentage of failures of "poured macadam" is due to poor screening. Fines should not be tolerated at all. The engineers of the Bureau of Public Roads suggest a maximum of 15 per cent, but 10 per cent should be the limit; 0 per cent should be aimed at.

There is no "finnickyness" about demanding good screening for macadam. Not only should the fines be removed but the range of sizes in any one grade should be restricted as much as possible for macadam stone and as wide as possible for concrete work. Thus, for macadam top course, 2–1½-inch stone is better than 2–1-inch. The former being more even sized has more voids, and voids are what is wanted.

SCREENING CONCRETE AGGREGATES.

On the other hand, concrete aggregates must have a minimum of voids; the greater the range of sizes the better the results. Stone ranging in size from 2 to 1½ inches has 50 per cent of voids. To make a dense concrete, one-half of the concrete must be mortar, or a mixture of cement and fine aggregates. Well-graded stone ranging in size from 2 to one-fourth inch, when intimately mixed, has 35 per cent of voids or less, leaving just that percentage to be filled with mortar. The efficiency of the cement in the latter case is increased from 35 to 50, which means over 40 per cent.

The proofs for this are abundant. Whenever and wherever coarse aggregates have been tested for the compressive strength of the resultant concrete the well-graded samples have stood the highest tests. In fact, from the vast number of experimental tests of fine aggregates, in which investigators all over the world have used three sizes designated as fine, medium, and coarse, plotting their results on what is known as the Feret triangle, it is evident that 70 per cent of the largest size permissible, 20 per cent of the medium, and 10 per cent of fine results in the best concrete. Why should not engineers insist that not less than 25 per cent nor more than 50 per cent of, say a 2–¼-inch concrete aggregate shall pass a 1-inch ring and why should not quarrymen be prepared to furnish it?

Again this is not pedantry. Why? A concrete made of all 2-inch stone and an ungraded sand is an absolute failure, it is full of voids and can be worked only with a detrimental excess of water. A great deal of similar concrete has gone into bases of pavements and it is to be wondered at than there are not more failures. This specification would be no hardship on any crushing plant. It is not necessary that the two or three sizes required be mixed in a bin; they can be loaded on the cars or trucks, one over the other and would be mixed in unloading, at least in the case of cars unloaded by shoveling. Mixing in bins is undesirable for another reason; a bin full of mixed sizes does not stay mixed. There is the well known separation by gravity, the large pieces always rolling to the outside of the pile. If the bin is large enough a rather close separation can be obtained by gravity.

MUST TAKE CONCESSIONS.

These, then, are concessions which quarrymen must take for the sake of results, thorough screening in macadam stone and thorough mixing in concrete stone, both within reasonable limits. That State testing engineers and chemists are willing to concede the ridiculous fractional sizes is apparent from their preliminary report. (Department of Agriculture Bulletin No. 55.) They recommend the following screen perforations: 3, 2, 1, ½, and ¼ inch. The nomenclature proposed consists of the numbers 3, 2, 1, ½, and 0, corresponding to the largest size contained in the grade. Thus No. 3 stone is 3–2 inches. Combinations of the numbers are proposed; thus No. 1, 2, 3 means a mixture of ½, 1, 2, and 3 inches. From the fact that this system of designating grades is the very contrary of the only system that has been at all firmly established in any branch of the industry, that of the granite quarries, it does not seem likely that its adoption universally could be successfully urged.

The logical system of describing grades seems the only one which we could hope to see adopted, that of specifying the limiting sizes. In this system stone for macadam base course would become 3–2 inches instead of No. 3 as is proposed, or instead of "ballast," "macadam," "2-inch stone," or "3-inch stone," as is now the confusing practice in different localities. Stone for cement concrete wearing surface would be simply 2–¼ inch instead of No. 12, as is proposed. One-half inch screenings would become "½ inch and finer." There can be no doubt that the nomenclature would be universally intelligible and, with the restrictions mentioned above, would be accurate.

The First Conference of State Testing Engineers and Chemists evidently considered only road work; the requirements of structural concrete must be considered and this will probably add another screen and grade—1½ inch round perforations. This will not be seriously objected to by crusher operators, 2 1½ inch stone for second course macadam will give very much better results than 2–1 inch. For concrete 1½–¼ inch material is vastly better, is as easily worked and will be more acceptable even for reenforced work than 1–½ inch.

STANDARDIZATION DESIRABLE.

The adoption of standard sizes is possible. The action of the Bureau of Public Roads in inaugurating a movement to bring this about is to be highly commended. Their engineers have shown a disposition to meet the producer more than halfway. If, in addition, other interests are considered, possibly the American Society for Testing Materials, the quarryman who has conformed his screening plant to the standards prescribed, would have the highest engineering authority to protect him from the whim or caprice of pedantic road builders and engineers, and other engineers on their part, would be assured of getting what they specify. To recapitulate:

I. The establishment of standard sizes of crushed stone adopted throughout the States is possible and highly desirable.

II. To accurately define a grade of stone, screen perforations, through and over which it passed should be given. It should be universally understood that (first) circular perforations are meant, (second) that the screen is a revolving one, and (third) that the screening plant is adequate so that any one grade shall contain not more than 10 per cent of fines (possibly 5 per cent) and not over 5 per cent oversize by laboratory tests and that (fourth) a mixture of various grades such as 2–¼ inch shall contain not less than 25 per cent nor more than 50 per cent of "fines" passing through a 1-inch screen, that is, through perforations having one-half of the diameter of the maximum sizes permitted in the mixture.

III. The following screen sections are proposed: 3, 2, 1½, 1, ½, ¼ inch.

IV. The nomencalture should be the logical one, simply stating maximum and minimum sizes.

[As pointed out by Mr. Scherer, any movement to standardize sizes in the commercial crushed stone product should be [illegible] will be readily indorsed by the industry. In fact the survey of present practice now completed by the Bureau of Public Roads would have been practically impossible without the cooperation of the operators concerned. Although Mr. Scherer sees no necessity for any further survey of present conditions, the Bureau of Public Roads feels that such a survey is not only desirable but [illegible] before [illegible] can be made which will be generally acceptable.—Editor.]

DECISION PREVENTS BUILDING.

Judge Paul Little, of the circuit court in western Arkansas, has sustained 65 appeals against assessments levied in the Scott County Road Improvement District No. 1, which was created two years ago to build 12 miles of road from Waldron west to the Oklahoma State line and from Waldron to Mansfield, on the Sebastian County line. The decision nullifies the district. The highway was to be a link in the Albert Pike Highway, from Colorado Springs to Hot Springs, and in the Bankhead Highway.

FEDERAL AID PROJECTS IN JULY

Federal aid projects approved in July were fewer than in any other month so far this year. The total number was only 46, the total mileage 394.061, while the estimated cost of all the projects approved or for which agreements were signed during the month is $3,530,511.66. The Federal aid allowance is $1,171,107.08.

South Carolina had the largest number of projects approved. These were six projects, with a total mileage of 57.8 miles, to cost $182,485.70, including the Federal aid allowance of $69,645.31. One of the projects is a concrete bridge to cost $22,545.82. Georgia followed South Carolina in the number of projects approved and in the total mileage. Her projects are five in number, with a mileage of 52.1 miles, to cost $188,435.12 and an allowance of $85,318.41.

Ohio leads in the total cost of roads approved and receives the largest aggregate allowance. Four projects, with a mileage of 24.89 miles, including bridges and culverts on one, and for concrete or bituminous surface and bituminous macadam roads, will cost $587,260.30, for which a Federal aid allowance of $131,500 is made.

The largest single project for the month is 11 miles of brick road in Ford County, Kans., estimated to cost $386,848.66, or $35,168.06 a mile. The allowance for this road is $58,027.30. The single project in Rhode Island is a bituminous macadam road, 2.04 miles long, to cost $93,747.50, or $45,954.70 a mile, the highest average cost per mile.

The greatest allowance for a single project is $111,839.79 for a concrete road in Oklahoma, 14.64 miles long, to cost $223,679.59.

The table gives in detail the projects approved and those for which the final agreement was executed.

FEDERAL AID PROJECTS APPROVED DURING THE MONTH OF JULY, 1918.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid.
Alabama	30	Geneva	10.85	Sand-clay	July 3		$23,285.69	$11,642.84
Arizona	2	Maricopa	3.78	Concrete		July 12	91,779.93	38,600.00
Connecticut	3	New London	7.80	Bituminous macadam	July 18		204,953.65	78,000.00
Florida	5	Desoto	2.50	Brick or asphaltic concrete	July 9		44,173.91	20,000.00
Georgia	21	Heard	8.00	Topsoil or sand-clay	do		27,658.62	12,000.00
	24	Cherokee	13.60	Gravel and topsoil	July 7		60,247.00	25,000.00
	28	Paulding	10.00	Sand-clay or gravel	July 17		30,767.00	15,000.00
	31	Dade	10.80	Topsoil and gravel	July 20		50,682.50	24,318.41
	32	Columbia	9.70	Topsoil or gravel	July 15		19,078.40	9,000.00
Illinois	3	Will	5.20	Brick	July 31		132,917.50	37,216.90
Iowa	20	Monroe	9.00	Earth	July 29		33,438.90	16,719.45
Kansas	14	Ford	11.00	Brick	July 3		386,848.66	58,027.30
Kentucky	7	Hart	10.00	Macadam surface treated	July 5		60,755.20	30,377.60
Michigan	8	Allegan	7.00	Bituminous macadam		July 12	158,399.13	70,000.00
	19	St. Joseph	3.97	Stone bottom with gravel top		do	49,011.38	24,505.00
Montana	9	Madison	10.00	Graded and drained	July 15		22,880.00	11,440.00
New Hampshire	18	Hillsborough	.90	Gravel	July 29		9,020.66	4,510.33
New Mexico	16	Lea	5.25	Macadam	July 13		25,450.70	12,725.35
	17	Eddy	5.00	do	July 9		18,385.40	9,192.70
New York	10	Rockland	2.47	Bituminous macadam or concrete	July 11		49,399.35	24,699.67
	11	Orange	2.59	do	do		51,726.40	25,863.20
North Dakota	5	Traill	25.15	Earth	July 18		23,519.10	11,759.55
	27	Benson	24.20	Graded earth	July 19		27,804.13	13,902.06
	29	Steele	12.15	Earth	July 5		21,627.10	10,813.55
	31	Lamoure	4.50	do	July 13		7,532.80	3,766.40
Ohio	15	Madison	12.80	Concrete or bituminous surface	July 15		331,136.52	70,000.00
	16	Clark	4.93	do	do		133,347.54	34,600.00
	17	do	4.47	Bituminous macadam	July 11		122,076.24	14,400.00
	22	Guernsey	2.69	Grading, bridges, and culverts	July 9		27,700.00	12,500.00
Oklahoma	5	Bryan	14.64	Concrete	July 15		223,679.59	111,839.79
Rhode Island	2	Washington	2.04	Bituminous macadam	July 19		93,747.50	20,400.00
South Carolina	2	Spartanburg	14.90	Concrete or brick, topsoil		July 27	121,716.58	48,577.87
	8	Bamberg	12.17	Sand-clay	July 24		26,122.36	10,771.14
	9	Newberry	5.63	Topsoil	July 19		16,178.58	8,089.29
	10	Lancaster	22.34	Gravel or macadam	July 24		49,296.50	17,000.00
	11	Chester	9.46	Sand-clay	do		53,769.42	18,784.88
	14	McCormick	8.25	Topsoil	July 31		14,573.02	6,000.00
	15	do	.15	Concrete bridge	do		22,545.82	9,000.00
Texas	22	Dallas	2.35			July 31	20,792.20	10,200.00
Virginia	13	Stafford and King George.	6.932	Gravel	July 24		59,263.28	29,631.64
Washington	13	Okanogan	1.077	Gravel with two bridges	July 31		33,195.80	13,789.67
	14	do	2.41	Gravel	do		16,556.70	8,278.35
	15	do	4.14	do	do		22,985.56	11,447.98
West Virginia	6	Mineral	.78	Concrete		July 15	14,530.84	6,381.00
	18	Tyler	1.00	do	July 5		25,650.00	6,650.00
	19	Ohio	.572	do	July 3	July 14	11,435.25	5,680.00
	20	Dodridge	.568	do	July 5		19,104.36	5,415.00
Wisconsin	10	Walworth	1.82	do		July 5	33,745.36	11,248.45
	11	Milwaukee	2.23	do		July 16	52,903.51	17,634.50
	18	Oneida	2.00	do		do	18,455.36	2,818.45
	32	Winnebago	3.52	do		July 31	74,721.20	24,907.07
	33	Fond du Lac	3.70	do	July 7		74,990.30	24,956.33
	48	Monroe	11.05	Earth	July 24		42,500.30	14,316.66
	49	Waupaca	10.10	Earth, surfaced in part	do		31,861.25	10,620.41
	50	Ozaukee	1.92	Bituminous macadam	do		17,556.88	5,852.29
Wyoming	20	Sheridan	8.02	Concrete or asphaltic gravel	July 2		169,380.45	80,200.00
Total			394.069				3,530,511.66	1,171,107.08

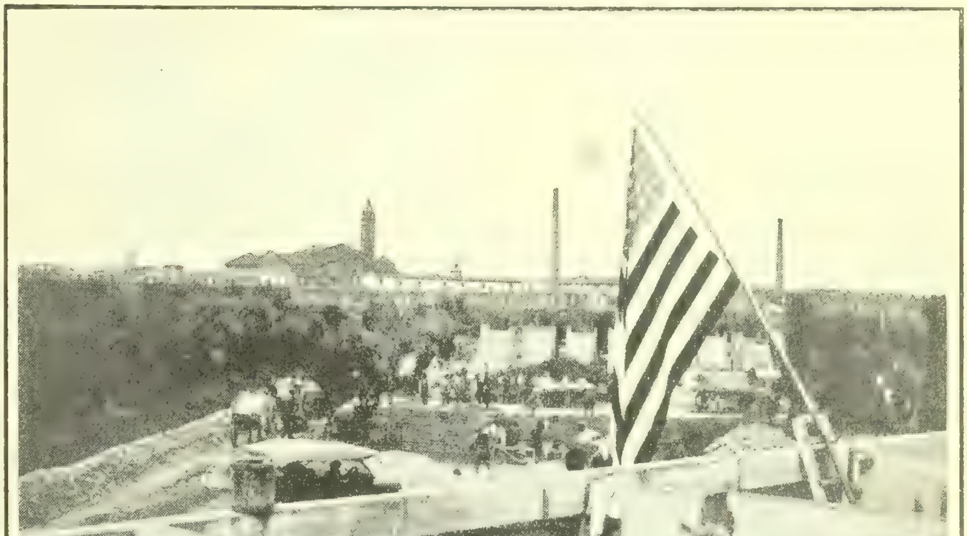
AMERICAN RED CROSS A BUILDER OF ROADS AND TOWNS IN ITALY

THE American Red Cross in its wonderful work for the victims of war has developed activities in a hundred different directions. It is not only caring for the wounded and sick and feeding the hungry, but is working most effectually to house the homeless refugees from the battle devastated lands.

The Red Cross forces have now been in Italy for several months. They preceded the arrival of American troops on the Italian front, and gave to Italy the first demonstration of American participation in the struggle that country is making. Early reports which came from Italy showed the enthusiasm with which the first contingents were welcomed, and later ones coming from time to time emphasize the various activities the workers are engaged in.

The work in caring for the refugees from the war zone in northern Italy has attracted much attention. There have been great numbers of these refugees, and homes have had to be found for them. The Red Cross representatives have undertaken and carried out this task. In doing this the Red Cross has built houses, even complete villages, with streets, stores and schoolhouses.

Just outside of Pisa there has been constructed a model village. It was built in cooperation with Italian architects, the work being done by Italian laborers. On April 1 the site was an apple orchard, by August 1 the village was complete, housing 2,000 people. The town contains houses, stores, shops, and workrooms, a church and school, all of cement and concrete. Great attention was paid to the water supply, sewage disposal and sanitation. The reports are that this Italian village will rival in sanitation all leading suburbs. The roads were constructed of native material, were well built, and it is hoped they will be a model to other small communities.



TOP: VIEW OF CONSTRUCTION WORK OF MODEL VILLAGE IN THE OUTSKIRTS OF PISA, ITALY, BY THE AMERICAN RED CROSS, LOOKING TOWARD THE CITY. BOTTOM: ROAD CONSTRUCTION IN THE MODEL VILLAGE.

SOME STATE HIGHWAY BUILDERS

ON THE opposite page are the portraits of State highway officials who are bringing their States to the front in the building of better roads. The list includes men active from New England and the South Atlantic coast to the Pacific Northwest. Other portraits and sketches will follow in future issues.

The highway work of Nebraska is looked after by the State engineer. The present occupant of the position is George E. Johnson. Mr. Johnson was born at Beatrice, Nebr., in 1881. He received degrees in civil, electrical and mechanical engineering at the Armour Institute, Chicago, in 1902. For 18 months he was employed on the St. Louis & Iron Mountain Railway in Arkansas. For the next two years he was superintendent of electrical construction for the Swift Packing Co. Following this he opened an office as consulting engineer at St. Joseph, Mo., remaining there until 1907, and afterwards maintained offices at Holton and Sabetha, Kans., and Falls City, Nebr. In 1915 he was appointed State engineer of Nebraska.

Thomas Harris McDonald, chief engineer of the Iowa State Highway Commission, was born in 1881 at Leadville, Colo. He attended the public schools of Poweshiek County, Iowa, and, for one year, Iowa State Teachers' College at Cedar Falls. In 1890 he graduated from Iowa State College in the civil engineering course. He was with the Chicago Great Western Railroad for a time on track work. In 1904 he became assistant professor of civil engineering at Iowa State College and placed in charge of road investigation work. In 1906 he was appointed highway engineer with the first State highway commission and held this position until 1913, when he was made chief engineer of the present reorganized State highway commission. He is also supervisor of State roads, a position which places him in charge of all highways and streets adjoining or upon State farms, State institutions, and the State capitol at Des Moines. Mr. McDonald is a member of the executive committee of the American Association of State Highway Officials.

The State road commissioner of Florida is William F. Cocke, born in Powhatan County, Va., February 7, 1875. Mr. Cocke started work as a rodman on a railroad survey. He was employed until 1907 on railroad location and construction work, and for a short time with the engineering department of Richmond, Va. In 1908 he took a position with the Virginia State highway commission, and advanced through various grades to division and maintenance engineer. In May, 1916, he was appointed State road commissioner of Florida. In this position he is the chief engineer of the State road department and its executive officer.

The legislature of 1917 greatly enlarged the powers and authority of the department and provided for the expenditure of 85 per cent of the State registration tax on motor vehicles for maintenance of State and State-aid roads in each of the 54 counties of Florida, all expenditures to be under the supervision of the State commissioner.

Charles Joseph Bennett was born in Frome, England, February 9, 1878, and was brought to this country when 2 years old. He graduated from the high school at Amsterdam, N. Y., in 1897 and from Union College in 1901, with the degree of bachelor of engineering. After his graduation Mr. Bennett was employed by the city engineer of Amsterdam. The following year he went to the Metropolitan Street Railway Co., New York City; in 1903 to the New York Central Railroad, and in 1905 to Hartford, Conn., with the New York, New Haven & Hartford Railway Co. In 1909 he entered the service of the State, working on the Saybrook Bridge. In 1910 he was made superintendent of streets of Hartford, and in 1913 was appointed by Gov. Baldwin State highway commissioner, and has remained in office through reappointments.

Commissioner Bennett has written a handbook, "Highway Engineering," has contributed to technical periodicals, lectured at Columbia College and the Sheffield Scientific School at Yale, and has delivered addresses throughout Connecticut and in other States on road questions and engineering topics. He is a member of the American Society of Civil Engineers, the International Permanent Congress de la Rute, a director of the Massachusetts Highway Association, and a member of the American Highway Association, American Road Association, National Highway Association, National Society of Civil Engineers, Connecticut Society of Civil Engineers, Rotary Club, and the University Club.

The State highway commissioner of Georgia, Warren Rabun Neel, was born near Atlanta, that State, in 1882. He was educated at the Georgia Military Institute, founded by his father, and the Georgia School of Technology. In 1901 he went to Mexico to work on the National Railroad of that country. For 12 years he maintained an engineering office in Mexico City and Tampico, being employed in various engineering enterprises. At one time he was superintendent of construction of the street railways of Mexico City. He abandoned that

(Continued on page 48.)

1. GEO. E. JOHNSON, NEB.
2. THOS. H. McDONALD, IA.
3. WM. F. COCKE, FLA.
4. CHAS. J. BENNETT, CONN.
5. W. R. NEEL, GA.
6. JAMES ALLEN, WASH.

STATE HIGHWAY MANAGEMENT, CONTROL, AND PROCEDURE

By M. O. ELDRIDGE, Assistant in Road Economics, G. G. CLARK and A. L. LUEDKE, Engineer Economist of the Bureau of Public Roads.

IN the August number appeared the first chapters on State highway management, control, and procedure. In this number are presented the chapters on ten additional States. Each one takes up the development and results of State participation and control of road work and the relation of State to local control; organization, personnel, duties and powers of State and local road officials; classification of State and local roads with particular reference to control and basis of payment, including methods of selection, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by the State and local officials over road construction and maintenance; sources of State and local funds, basis of allotment and apportionment of State funds, and the relation of State to local funds, and the amount available for road purposes during the latest calendar or fiscal year.

COLORADO

DEVELOPMENT.

State participation in road improvement in Colorado is of State-wide scope and consists of money aid, technical advice, and supervision, and was first evidenced in 1908 by the employment of State convicts on the improvement of certain roads designated by the legislature.

A highway commission was created in 1909 with advisory powers over all roads of the State and had at its disposal a fund for State-aid to the various counties.

The laws relating to State-aid and State highway officials have been modified and strengthened from time to time until at present the highway department of Colorado is well organized, has funds at its disposal for State participation in road work throughout the State, and exercises to a limited extent supervisory and advisory powers over local work executed by county officials.

A system of State roads comprising about 18 per cent of the total road mileage of the State composed of roads chosen by the various county boards with the approval of the State highway department has been designated as State routes from which a system of State highways will be selected for improvement with State and local funds by the State highway department.

The State legislature from time to time has provided special appropriations for the construction of bridges in various counties of the State.

At the close of 1916, about 1,800 miles, or 4½ per cent of the total mileage of public roads had been improved by hard surfacing. In 1916, $607,728 of State funds and $662,829 of local funds were expended by or under the supervision of the State highway department. The total expenditures by State and local forces reached $2,313,208 in the same year. In 1917 they totaled $2,570,000.

State participation in road work was delayed by lack of funds during the period 1911 to 1913, due to the fact that the law providing State funds for construction purposes was declared unconstitutional.

ORGANIZATION.

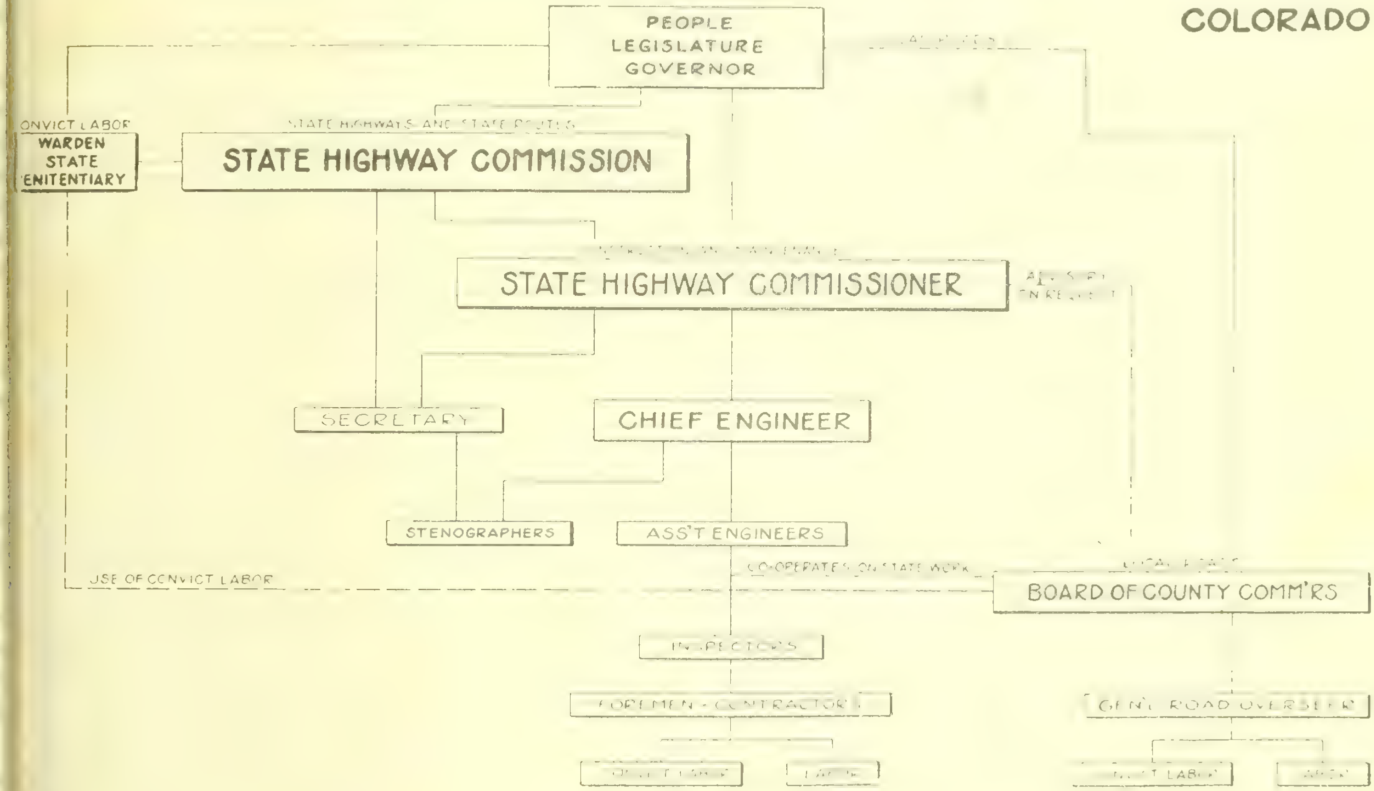
The organization of the road forces of the State and the relation existing between them is shown by chart on page 25.

State.—The State highway department, composed of the State highway commission, State highway commissioner, his assistants and employees, is in charge of all road improvements for which the State provides funds wholly or in part.

The commission is composed of five members appointed by the governor for terms of five years, one being appointed each year from one of the five districts into which the State is divided by law. The commission has general charge over the establishment, revision, construction, and maintenance of the proposed State highway system; the financial affairs of the State highway department, and the preparation of a yearly budget of proposed operations of the department. The affirmative vote of all members is required for any action proposed. In case they fail to agree, decision is made by the governor.

The State highway commissioner may be removed from office by the vote of all members of the commission. If they fail to agree, the governor, acting with the majority of the commission, decides the matter. In case of removal the successor to the commissioner is appointed by the commission to serve the remainder of the term for which the removed official was appointed. The State highway commissioner is appointed by the governor for a term of four years and is required to designate an employee of the department to act as deputy in case of absence or incapacity of the commissioner.

The commissioner is the executive official of the department and, subject to the orders of the commission, is in charge of all matters pertaining to road improvement financed wholly or in part by State funds. He appoints from lists of eligibles furnished by the commission such assistant employees as may bebneeded. The State civil-service regulations do not extend to these employees. All payments made out of funds at the disposal of the department must bear the approval of the commissioner.



County.—County supervision over road affairs is vested in a board of commissioners, consisting of three members elected for a term of four years. The county clerk and county treasurer, elective officials, are clerk and fiscal agent, respectively, of the board. In all counties of the State, except Denver and those counties in which the road funds are less than $12,000 annually, the county board may elect a county road supervisor who is skilled in road building and who acts as the executive official of the board in all matters pertaining to roads and bridges under their control, and who has power to form road districts for the purpose of road dragging and other minor repairs. The board may divide the county into districts and appoint a general road overseer who, with the consent of the board, appoints deputy overseers for each district. The board has the power to levy and raise taxes and to enter into contracts for road and bridge improvement.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 39,739 miles of public road in Colorado are divided by statute for the purpose of fixing responsibility for construction, control, and maintenance into two groups, State highways and county highways.

State highways.—These comprise the roads chosen by the State highway commission from the system of 7,083 miles of State routes. They are improved under the immediate control of the State highway commissioner with State and local funds and maintained by State forces at the joint expense of the State and county.

The State route system comprises all roads designated prior to 1917 as State highways and such other roads as in the opinion of the commission should be added thereto. It is the intent of the State law that the State highways shall not be set apart from the State route system unless they have been improved or until funds are available for their improvement. State routes may be improved and maintained as State routes by means of a joint fund supplied by the State and county in such proportion as may be mutually agreed to by the State and local officials. Federal funds, with the approval of the Secretary of Agriculture, may be used for the construction of either State highways or State routes. Construction of either the State highways or State routes is done under the supervision of the State highway commissioner either by force account, convict labor, with the approval of the warden of the State penitentiary, or may be let by contract. When executed by contract, let by the State or by the State and county, payments are made on order of the State highway commissioner.

County highways.—These comprise all public roads of the State not specifically designated by the State highway commission as State highways or State routes. They are constructed and maintained by county forces with county funds. Convicts from the State penitentiary, on application of the county board and with the approval of the warden of the penitentiary, may be employed on county roads. All excess expense in connection with such employment is borne by the county. State routes are included in this system until withdrawn by action of the State highway commission.

REVENUES.

The State highway fund for the year ending November 30, 1917, was composed of receipts obtained from the following sources:

1. From the proceeds of a ½ mill State-wide tax levied on all taxable property in the State, $592,615.

2. By appropriation by the State legislature.

3. Receipts of the internal-improvement permanent fund and the internal-improvement income fund, $153,110.

4. From 50 per cent of the fees levied on motor vehicles and chauffeurs for license purposes and from 50 per cent of the fines and penalties accruing from violation of the motor-vehicle laws, $141,966.

5. From all public contributions, including those made by the United States Government or a department thereof. Such funds are to be expended in strict accordance with the terms of the contributions.

Local. From 50 per cent of the fees levied on motor vehicles and chauffeurs as license fees, and from 50 per cent of the fines and penalties accruing from violation of the motor-vehicle laws. This fund is added to the proceeds of a tax levied by the county board at a rate which may not exceed $1 on each $100 of valuation. The combined fund is known as the county road and bridge fund.

Bonds.—Bonds may be issued for road and bridge purposes by the county boards when authorized by a majority vote of the tax-paying qualified electors of a county. Bond issues are limited as follows: Counties having a valuation between one and five millions may issue bonds to the amount of $12 for each $1,000 of valuation. When the valuation of a county exceeds $5,000,000, the limit is $6 for each $1,000 of valuation.

NEW YORK COST OF ROAD LABOR.

In the Ogdensburg region in Northern New York the labor of a man and team on the State road is now costing $7 a day.

CONNECTICUT.

DEVELOPMENT.

By its early start, its well founded policies, its liberal appropriations, and its gradual development from local to centralized control, Connecticut has, by State participation, accomplished a fairly comprehensive and connected system of improved roads. The State now controls approximately 11.5 per cent of the road mileage and contributes about 74 per cent annually of all road expenditures.

The State highway department was organized in 1895 with three commissioners in charge and a State-aid appropriation to counties and towns of $150,000 for the biennial period. The State was divided into three districts and one commissioner had charge of the work in each district. The law provided that the State, county, and towns each pay one-third of the cost of State-aid roads.

In 1897 State control was still further centralized by placing one commissioner in charge of all State-aid work. The organization has not been changed since that time and the administrative head of the department has been changed only once. The 1897 law limited State aid to towns only, and the State and towns were to share equally in the cost. The law of 1899 increased the State's share to two-thirds in the richer towns and three-fourths in the poorer towns. In 1907 this was increased to three-fourths and seven-eighths, respectively.

A connected system of trunk-line roads, over which the State exercises complete control and pays the entire cost of construction and maintenance, was provided in 1907. This system includes 1,500 miles, of which 950 miles have been improved. There are about 520 miles of road which have been surfaced, and 195 miles reconstructed through the aid of the State.

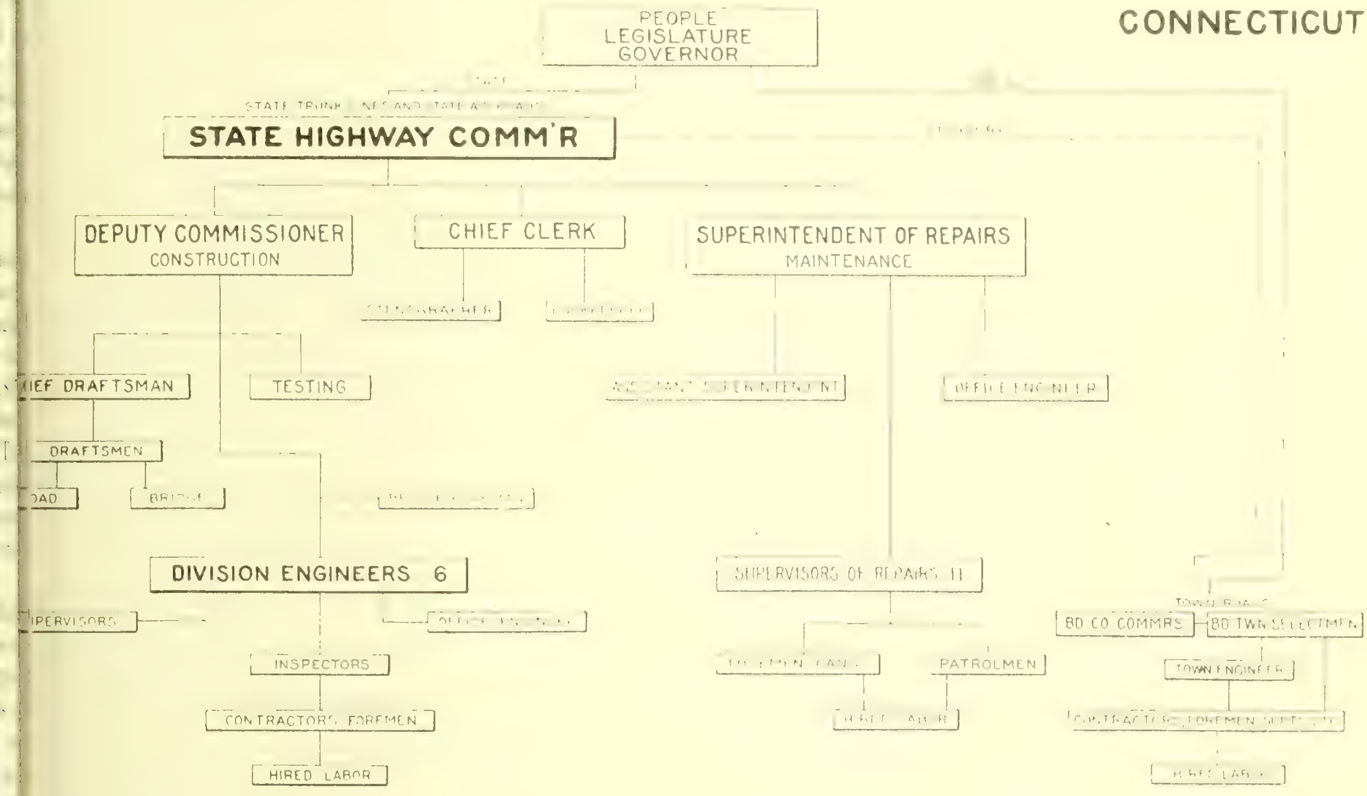
State funds available for trunk-line and State-aid work for the biennial period October 1, 1917, to September 30, 1919, will amount to approximately $7,224,000, including estimated receipts from automobile registration fees, while the total State funds expended for road work from 1895 to September 30, 1917, amount to $20,923,752. The trunk-line and State-aid roads are systematically maintained by the State under the patrol and gang systems. Out of a total of 14,061 miles of public roads, 3,100 miles, or about 22 per cent, had been surfaced up to January 1, 1917, thus showing that the State has been responsible for about one-half of the total improvement.

In 1916 the State expended $1,950,948 for construction, maintenance, and engineering, of which $85,000 was contributed from local funds. In addition to this, the local authorities expended for the same period approximately $1,250,000, making in all $3,285,948. In 1917 the total expenditures from all sources were $4,004,225.

ORGANIZATION.

The highway organization of the State and the relation existing between the local and State forces is shown in the diagram on this page.

State.—The State highway department is controlled by a commissioner appointed by the governor with the advice and consent of the senate for a term of four years. The law provides that he must be a capable road builder. The present commissioner is not only the administrative and executive head of the department, but, being an engineer,



ie also has charge of the engineering work. All ubordinate employees are appointed by the comnissioner and are under the civil service.

The department is divided into two main branches, amely, construction and maintenance. A deputy ommissioner has charge of construction, with six livision engineers under him in charge of field work. here is also under the deputy commissioner a bridge oreman, who has charge of all repairs on trunk-line ridges. A superintendent of repairs has charge of aintenance with one assistant superintendent and 1 supervisors of repairs in charge of field work. he clerical and accounting work of the department s handled by a chief clerk.

Local.—The boards of selectmen of the various owns have full authority over public roads other han trunk-line and State-aid roads. These boards sually consist of three or more members elected nnually at the town meetings. Some towns have a own engineer or other official who has immediate harge of town roads. If selectmen refuse or neglect to maintain town roads, the boards of county commissioners of the various counties may have the work done when petitioned to do so; otherwise, county officials have practically no authority over roads, and the power to take over roads for maintenance is seldom exercised.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Connecticut, comprising 14,061 miles, are, for the purpose of fixing responsibility of construction, control, and maintenance, divided into three groups—trunk-line, State-aid, and town roads.

Trunk-line roads are selected by the State highway commissioner with the approval of the legislature, and comprise 950 miles of the most important main traveled roads of the State. They are constructed and maintained entirely at the expense of the State with funds appropriated solely for use on trunk lines. The State highway department has complete control and supervision of construction and maintenance of trunk-line roads, and of all bridges on such roads having a span of 25 feet or more. The highway department also has charge of the elimination of grade crossings and other dangerous places on trunk lines.

When bridges of 25-foot span or over on trunk-line roads are constructed within a town, the cost is borne equally by the State and town. If such bridges are built between towns, one-half of the cost is paid by the towns in proportion to the assessed valuation of each. If located between counties, the counties are required to pay one-fourth each of the cost. Trolley companies using bridges are required to pay one-third of the cost.

All work costing more than $1,000 is let by contract by the State highway commissioner. Trunk-line roads are maintained by the State under the gang and patrol systems, the gang system being largely used. Funds for this purpose are derived from State appropriations and the receipts from the automobile registration fees.

State-aid roads, comprising 520 miles on January 1, 1918, are designated by the selectmen of the various towns with the approval of the State highway commissioner. They are constructed and maintained under the supervision of the State highway department. They are not links in a comprehensive system, but an effort is being made by the highway department to have them connected on continuous lines. Surveys, plans, specifications, and estimates are made by the State and submitted to the town selectmen for approval. The work is done by contract let by the State highway commissioner. Towns may submit bids for doing the work in their own limits and work costing less than $1,000 may be let without advertising.

In towns having an assessed valuation exceeding $1,250,000 the State pays three-fourths the cost of construction, and in towns having a valuation of $1,250,000 or less, the State pays seven-eighths of the cost. Payments are made by the State until the State allotment is exhausted, then the State comptroller bills the town for its share of the cost. Upon completion of construction, the State assumes responsibility for maintenance, but the towns are required to pay one-fourth of the cost.

Town roads include all other roads not referred to in the above groups. The work of construction and maintenance of town roads and bridges is done under the direction of the town selectmen.

REVENUES.

State.—Appropriations are made by the legislature for two-year periods. The amount appropriated and the purposes for which the appropriations were made for the two-year period, October 1, 1917, to September 30, 1919, are as follows:

Trunk-line construction, $1,500,000.
Trunk-line maintenance and reconstruction, $1,000,000 and auto fees.
State-aid construction, $1,000,000.
State-aid maintenance and reconstruction, $350,000 and refunds.
Trunk-line bridges, $450,000 and refunds.
Elimination of dangerous conditions on trunk lines, $75,000 and refunds.
Thames River bridge, $450,000.
Drawbridges and ferries, $66,700.
Niantic River bridge, $80,000.
Miscellaneous for salaries and administration of highway department, $253,000

To this should be added the receipts from automobile registration fees which are used for the maintenance of trunk-line roads, and will amount to approximately $2,000,000 for the two years referred to, thus making a grand total of State funds available for the two fiscal years, exclusive of refunds, of approximately $7,224,700, or $3,612,350 per annum. These funds are expended at the discretion of the State highway commissioner, except that no tow can receive more than $20,000 State-aid mone during a two-year period.

Local.—It is estimated that the towns are no expending under local control approximatel $1,250,000 per annum for construction and mainte nance of local roads and bridges. The funds fo town roads are usually paid from the town budge tax.

Bonds.—No local bonds are issued, but from tim to time the State has issued bonds for roads an other purposes. In 1907, and again in 1911, whe deficits occurred in the State treasury, there wer issued to cover them a total of $7,000,000 of Stat bonds, the larger portion of which was appropriate to pay the State's share of State-aid and trunk-lin roads.

DELAWARE.

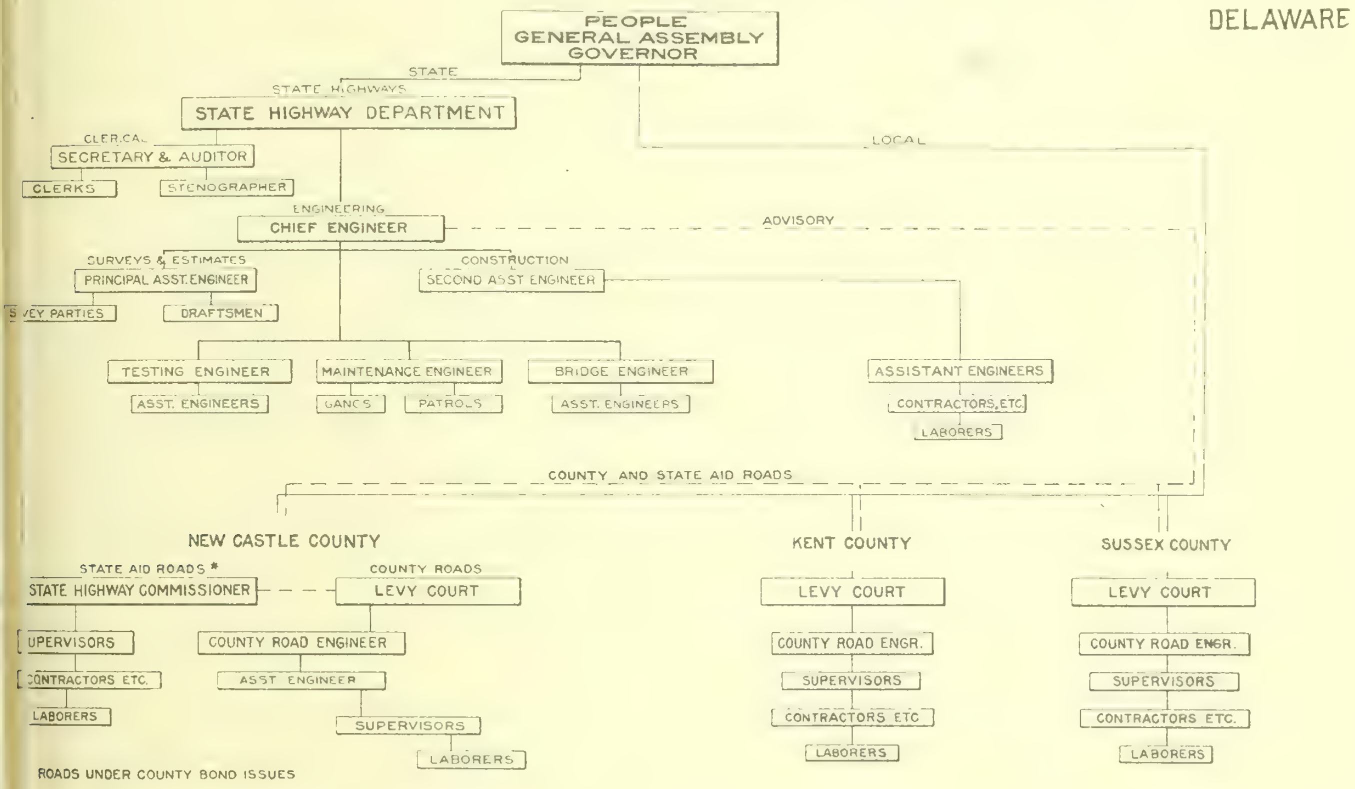
DEVELOPMENT.

State participation in road work in Delaware is o recent origin. The present policy of the State is t build and maintain entirely at State expense system of State highways and to aid the counties b annual donations amounting to $10,000 for eac county. The State will exercise complete contro over the proposed system of State highways whic will include about 5 per cent of the total roa mileage of the State.

The first State-aid law was enacted in 1903 This provided money aid to the amount of $10,00 per annum for each of the three counties to b expended with an equal amount raised by th counties under a State highway commissioner fo each county. In 1905 this law was changed b providing a State highway commissioner for each o the counties of New Castle and Kent. Shortl after this law was enacted, Kent County ceased t avail itself of the right to use the State highwa commissioner, and all State-aid work was handle by county engineers in Kent and Sussex from tha time to the present. From 1903 to 1917 about 18 miles of road, more or less, disconnected, were constructed under this State-aid system. In additio to the money appropriated for each county, $1,00 was appropriated by the general assembly, to pa the salary of the State highway commissioner fo New Castle County.

The legislature of 1917 created a State highwa department and provided for the construction reconstruction, and maintenance of a system of State highways entirely at the expense of the State This system is to include about 650 miles of road and the cost of construction and reconstruction is to be paid from the fund derived from State bond issues, proceeds of the automobile licenses and State ncome tax. Thus the State has two systems of oads under its jurisdiction or to which it contributes noney aid, namely, State-aid roads and State highvays, each controlled by separate and distinct sets f officials with apparently no coordination of uthority.

Local road and bridge expenditures not under tate control now amount to approximately $250,000 er annum. Total expenditures from all sources in 917 amounted to $321,600. The State has 3,674 niles of road, of which 275 miles, or 8 per cent, have een improved.



ORGANIZATION.

The highway organizations of the State and the lations existing between them and the local rces are shown on the diagram above.

State.—The State highway department which has ntrol of the construction and maintenance of ate highways is composed of the governor and ur members appointed by the governor. The rms of office of the first commissioners appointed e two, four, six and eight years, respectively. ter the expiration of the terms of the first commisoners they are appointed for the full term of eight ars. They serve without compensation and not ore than two members shall belong to the same litical party. One member must be a resident of e city of Wilmington, one a resident of New stle County outside of the city, one from Kent unty, and one from Sussex County. The adminrative head of the department is the chief engineer, who is appointed by the State highway commission, three members concurring in his appointment. He must be a civil engineer not less than 30 years of age, shall have been in active service of his profession for 10 years, and shall have had responsible charge of engineering work for at least five years, and shall be qualified to design and direct road work. Graduation from a school of engineering of recognized reputation shall be equivalent to two years of active practice. The chief engineer may be paid a salary of $7,500 per annum. He has charge of all engineering work for the highway commission, and upon its approval may act as consulting engineer for the counties. He must approve the construction of the bond-built roads in New Castle County. The commission is authorized to appoint a secretary, whose salary may not be more than $3,000 per annum. On the recommendation of the chief engineer, the department also appoints such technical and clerical employees as may be necessary.

A State highway commissioner for New Castle County controls the roads constructed in that county with joint State and county funds, and cooperates with the levy court in the construction of roads improved with funds derived from bond issues. He is appointed by the governor for a term of four years and must be a resident of New Castle County. If he also holds the position of county engineer, his salary is $2,500, of which the State pays $1,000, and the county of New Castle $1,500.

The State aid funds appropriated for Kent and Sussex Counties are expended under the direction of the county engineers of those counties without any State control or jurisdiction. The annual appropriation of those two counties, therefore, practically amounts to a donation on the part of the State, but the funds appropriated by the State must be expended together with an equal amount raised by the counties for improvement and maintenance of roads.

Local.—The levy courts are responsible for the improvement, repair, and maintenance, financing, and management of local roads in each county. In Sussex County the levy court is composed of three members, who are elected for 6 years, each of whom receives $1,200 per annum. In Sussex County the levy court appoints a county engineer at $1,800 per annum. All local and State aid work is carried on under the immediate direction of the engineer and the supervisors who are appointed by him. In Kent County the levy court of 10 members appoints the county road engineer at $1,500 per annum. All local and State-aid work is handled by the engineer and the supervisors, of whom there is one appointed by the levy court for each district or hundred. There are seven members of the levy court in New Castle County, in which permanent improvements are carried on under the direction of the State highway commissioner for the county and such supervisors as may be appointed by him. These supervisors receive $3 per day for time actually employed and must be practical men experienced in road construction. All maintenance work in New Castle County outside of the city of Wilmington is handled by the county supervisor who is appointed by and reports to the county engineer.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Delaware are for the purpose of fixing responsibility for construction, control, and maintenance, divided into three groups, namely, State highways, State-aid roads, and county roads.

State highways.—This is a tentative system of roads, at present embracing about 650 miles, which it is proposed to take over and permanently improve and maintain entirely at the expense of the State. The entire jurisdiction over this system for selection, construction, and maintenance is invested in the State highway department established during 1917. No State bonds have been issued, no State highways have yet been constructed. However, the State has taken over part of this system, about 19 miles of road known as the Coleman Du Pont Boulevard, which was constructed by Gen. Coleman Du Pont entirely at his own expense. That portion which is already completed starts at the Maryland line in the southern part of the State and extends in a northerly direction toward the city of Wilmington. Gen. Du Pont has agreed to pay for the completion of this road to Wilmington, a distance of 80 miles, making the total of the Du Pont Road approximately 100 miles.

State-aid roads.—Those which are built from joint State and county funds under the direction of the State highway commissioners of New Castle County, and the county road engineers of Kent and Sussex counties. About 180 miles were constructed up to January 1, 1917. Contracts are let by the levy courts and the roads when completed are maintained at the expense of the counties.

County roads.—All roads except those above referred to are classed as county roads and are under the jurisdiction of the levy courts. All State-aid roads after completion are maintained by the counties as county roads.

REVENUES.

State. The State treasurer is authorized to issue State bonds with which to construct a system of permanent State highways. Two sources of funds are provided with which to pay interest and principal of these bonds, and for the support of the State highway department as well as for the maintenance of State highways, namely, the gross receipts from automobile registration fees and the gross receipts from the State income tax less $250,000 per annum, which goes to public schools. After deducting enough each year to pay interest on the bonds outstanding and 2½ per cent of the total of outstanding bonds for sinking funds, the balance is used for the support of the State highway department and for the maintenance of the State highways. The funds are appropriated at the discretion of the State highway department on the budget system. Additional bonds may be issued whenever the funds available will justify. The amount of bonds that may be issued will depend, of course, on the amounts received from the sources above referred to and upon amounts which will be necessary to support the highway department and maintain State highways. No State bonds have as yet been issued. During 1917 the gross receipts from the automobile registration fees amounted to $140,000, but the general assembly provided that $50,000 of this should be reserved, leaving $90,000 for the purpose outlined. In 1918 and thereafter the gross receipts from this fund are to be placed to the credit of the State highway fund to be used as indicated.

The general assembly in 1917 appropriated $10,000 for State aid to each of the three counties for the years 1918 and 1919; also $1,000 per annum toward the salary of the State highway commissioner from New Castle County, making a total of $31,000 per annum for the two-year period.

Local.—Special taxes to meet State aid and regular taxes for maintenance are levied by the levy courts of the respective counties. These local funds amount to approximately $250,000 per annum.

BONDS.

State.—Bonds shall bear not to exceed 4½ per cent interest and must be paid within 40 years, but the bonds must be issued subject to call after one year from the date of issue, and if called, the State buys them at 103. A sinking fund is established by the State treasurer with which to retire the bonds amounting to 2½ per cent per annum of the total bonds outstanding.

Local.—Most of the funds with which roads have been permanently improved in the various counties ave been derived from county bond issues. On January 1, 1915, Kent County had $30,000 of road bonds outstanding and New Castle County, $1,250,000. Sussex County had not issued any bonds. The general assembly in 1917 authorized additional ssues as follows: One hundred thousand dollars in Kent County, $600,000 in New Castle County, and $1,000,000 in Sussex. In New Castle and Sussex he bonds may bear not to exceed 4½ per cent nterest, while in Kent 5 per cent may be paid. All of the county bonds are to be deferred serial type, he first payment falling due 10 years from the date of issue, and the last payment, 39, 43, and 49 years n Kent, New Castle, and Sussex, respectively. All of the bonds, however, may be issued subject to call fter five years, at which time they may be redeemed t 5 per cent.

FLORIDA.

Development.—State participation in road work n Florida has been of such small amount as to be elatively unimportant, as the State road department was not created until 1916 and then acted only n an advisory capacity over such road matters as ere brought to its attention. However, in assenting to the provisions of the Federal aid road act in 917, the legislature provided a limited amount of nds to be expended by or under the supervision f the State road department in the construction nd maintenance of a system of State roads and as id to counties in the construction of certain designated roads, and extended and broadened the owers and duties of the department.

Road improvement in Florida has, heretofore, een left to the various counties, and while about) per cent of the road mileage of the State has been ard surfaced, the various counties have not followed niform standards of construction or cooperated ith each other to secure a well connected State-ide road system.

Under the new powers delegated to the State road department the State will be represented in the construction and maintenance of certain roads and will have limited general supervision or powers over a large amount of local construction and repair.

In 1916, the State road department expended $10,484 in educational and advisory work, while about $4,000,000 was expended by the counties for road construction and maintenance. In 1917 the total expenditures for road and bridge purposes were $6,384,797.

The total amount of mileage included in the State road system has not been made available for publication.

ORGANIZATION.

The organization of the highway forces of the State and the relation existing between them is shown on page 32.

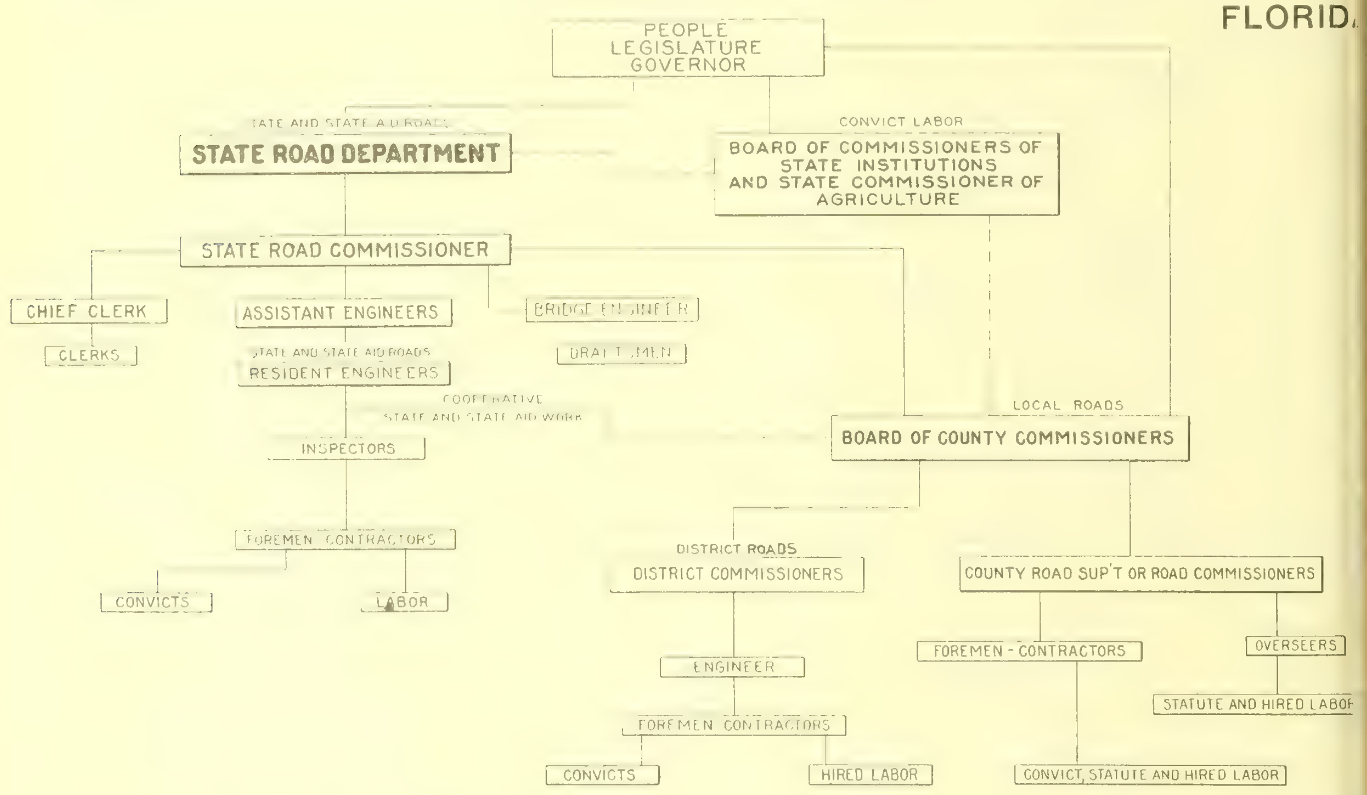
State.—The State road department consists of five nonsalaried members appointed by the governor for terms of four years, one member being resident in each of the four Congressional districts of the State, and one member from the State at large. A chairman and secretary are elected annually from the membership of the department. The State road commissioner, who is required to be a competent and efficient engineer well versed in the building of good roads, is selected and employed by the department. Such other assistants and office force as may be required by the amount of work in hand are provided by the department. In addition to the duties shown on the chart, in the appendix, the State road department is required or empowered to designate a system of State roads and a system of State-aid roads. The department may, when requested by local officials, take charge of construction and maintenance of local roads or bridges.

The department also is directed to inspect the books, records, methods of construction and repair of roads and bridges of the various county boards of commissioners, and to point out improper practices or procedure, and to bring the matter to the attention of the governor of the State upon neglect or refusal of the board to remedy the conditions or practices criticised by the State road department. The governor has the power to remove county officials for malfeasance or misfeasance and to appoint their successors. The department is required to compile and to furnish road officials and other interested citizens of the State, data relative to road mileage, methods and materials of construction and repair, and to publish road maps when practicable.

County.—Each county is governed by a board of five commissioners elected from the five districts of the county. This board has full control over all roads of the county except the mileage included in the State or State-aid system. The board may appoint a county road superintendent to take active charge of the road and bridge work of the county, or the commissioners may assume charge of the work in their respective districts and appoint overseers to take local charge of the work.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The roads of Florida, comprising about 18,000 miles, are for the purpose of fixing responsibility for construction, control and maintenance, divided into three groups: namely, State roads, State-aid roads and county roads.



State roads are designated, constructed, and maintained by the State road department. State funds for their construction and maintenance are provided by the legislature or by a State-wide tax. Federal funds allotted to the State are expended on State or State-aid roads.

State-aid roads are selected by the State road department in cooperation with the county board of commissioners. The cost of plans and estimates is paid jointly by the State and county. The cost of construction is borne equally by the State and counties but Federal funds may be substituted for State funds. The State road department furnishes the engineer, and the county pays the field and travel expenses. Construction is under control of the State road department, and may be executed by force account, convict labor, or by contract.

Male convicts from the State Penitentiary may be utilized for road construction and maintenance purposes as follows: Not to exceed 300 may be placed at the disposal of the State road department. All expenses incurred on account of convicts so detailed are paid by the State road department out of funds provided for road construction and maintenance purposes. Such additional convicts as may be available may, when requested, be leased to the county boards of commissioners. Such convicts are at all times subject to supervision by, and the rules and regulations of, the board of commissioners of the State institutions, and the State commissioner of agriculture. When the convicts are leased to counties, the county pays either $1.00 or $10.00 per month per man, the rate being dependent upon the physical conditions of the convict.

When State or State-aid work is to be left to contract, due publicity by the State road department is required. The contract is let by the State road department to the lowest responsible bidder conditioned on his filing an acceptable bond.

Payment of State funds may not be made except on a voucher signed by the secretary and approved by the chairman of the State road department, the voucher being drawn against the Comptroller of the State, who issues his warrant to the State treasurer.

State-aid roads are maintained under the supervision of the State road department. One-half of the cost of maintenance on these roads is paid by the county.

County roads, comprising all other roads of the State, are opened, constructed, and maintained by the county boards with county funds. However, the State road department is required on the request of the county officials to detail competent assistants to advise with local officials or to take harge of construction of county roads or bridges.

REVENUES.

State.—A state-wide tax not exceeding one-half mill on each dollar of valuation of the taxable property of the State is levied each year. The proceeds of this tax estimated at $150,000 for the fiscal year 1918 are at the disposal of the State road department for construction and maintenance of State and State-aid roads. The legislature provided appropriations of $56,000, $112,000, and $168,000, available for the years beginning July 1, 1916, 1917, and 1918. These sums are not in addition to the proceeds of the tax levy fund, as these amounts are deducted therefrom and the balance remaining, if any, may be used by the State road department. Fifteen per cent of the net revenues, estimated at $40,000 for the calendar year 1918, from the licensing of motor vehicles and chauffeurs is set aside for he maintenance of the State road department.

County.—Eighty-five per cent of the net revenues rom licensing of motor vehicles and chauffeurs is et aside as a State maintenance fund for the maintenance of State and State-aid roads and bridges, and is apportioned among the counties in proportion to the total State tax paid by each ounty into the State treasury. When this fund s not required for State or State-aid road maintenance purposes, it may be expended for new contruction of roads of those classes.

The county boards may levy a special tax at a ate of not less than 3 or more than 8 mills on each dollar of taxable property for road and bridge purposes, provided that 50 per cent of the amount ollected within the corporate limits of towns and ities be delivered to the municipal authorities for treet improvements. Special districts of the county may be formed and may levy additional taxes for oad improvement.

A labor tax of not to exceed five days' labor is equired of each person residing more than 30 days the county and who does not pay any real or ersonal tax. This tax may be commuted in whole r in part by the payment of $1 for each day of bor required.

BONDS.

Sinking-fund bonds may be issued by counties or pecial districts when authorized by a majority of the voters resident therein. The amount of the sue, the term, and the rate of interest are specified the proposal submitted to the voters.

On January 1, 1915, there was outstanding a total bonded indebtedness of $5,959,199.22 incurred by counties for road and bridge construction.

These bonds bore interest at 5 and 6 per cent and ranged from 20 to 30 year terms.

IDAHO.

Development.—State interest in road and bridge improvement in Idaho has been manifested intermittently since 1905. During the period 1905 to 1913 the legislature provided additional funds for various local projects in communities unable to bear the financial burden imposed by the construction of improvements tending to be of more than local benefit.

With the organization of the State highway department in 1913 and the provision of funds for the support thereof, State participation in road and bridge improvement became a fixed State policy, and is now being extended to a system of State highways which comprises about 9 per cent of the total road mileage of the State and which has been selected with the approval of and is administered by the State highway commission.

Idaho, in common with other thinly settled States, is handicapped by a lack of funds necessary to construct roads and bridges essential to the encouragement of immigration and the development of the mining and timber resources of the State. However, State funds in combination with local funds are being expended for substantial bridges and culverts and the grading of rights of way selected to insure proper alignment and easy gradients. While the need of surfaced roads is recognized, the policy of the State highway department has been to defer that stage of construction until more funds are available, as the graded earth roads with but few exceptions serve the present needs of the public, and surfacing may be added at a later date when a larger amount of funds becomes available.

At the close of 1916, 800 miles or 3.3 per cent of the total State mileage had been improved. Of this mileage 413 miles have been built under State supervision.

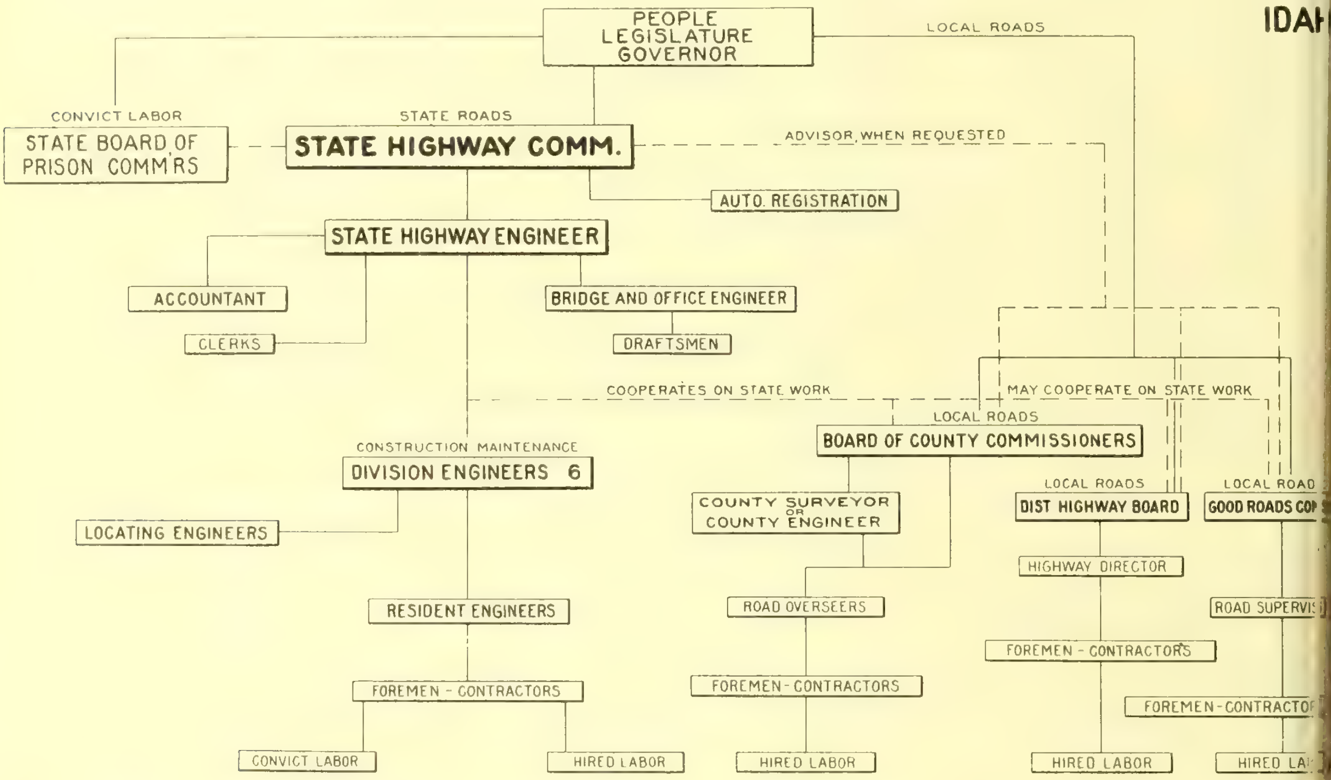
Road and bridge expenditures during 1916 amounted to $100,057 of State funds and $348,061 of local funds expended by or under the supervision of the State highway department.

The total expenditure by all road forces of the State for the same period reached $1,948,118. The State thus exercised supervision over 23 per cent of the total expenditures. In 1917 the total was $2, 092,723.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown in the chart on the next page.

State.—The State highway commission is composed of the secretary of the state and two members appointed by the governor for terms of three years. The State highway engineer is selected by the commission and serves as the executive official of the State highway department. He selects with the approval of the commission such office and field assistants as may be required to carry out the duties imposed on him by law and the orders of the commission. Field operations are carried out under the control and direction of six division engineers who report to and represent the State highway engineer. The State highway department has full control over construction, financed wholly or in part with Federal or State funds, and is responsible for the proper maintenance of such work when completed.



County.—Road affairs in the county are administered by a board of county commissioners, elective officials, who levy and expend the proceeds of the ordinary taxes prescribed by general State law for the construction and repair of county roads and bridges. Whenever improvements financed by special taxes or the proceeds of local bond issues are contemplated, a special highway district or a good roads district may be formed within the limits of the county and an administrative board consisting of three elective members is chosen to take charge of the work. In the case of the good-roads district, the board is dissolved upon completion of the project. The highway district is an organization of a more permanent nature, the members of the board being elected fo terms of four years and the organization may continue until dissolved by action of the residents o the district. The county board or district boar may cooperate with the State highway commissio in the construction of State highways located withi the limits of the county or district, and may construct under their exclusive authority roads o local importance. The county or district ma employ an engineer to supervise work not unde the supervisory control of the State highway department. Road overseers are appointed by coun boards to supervise statutory or paid labor used f minor repairs or ordinary maintenance.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 24,386 miles of public road in Idaho are, f the purpose of fixing responsibility for contr construction, and maintenance, divided into tw groups, namely, State highways and county roads

State highways.—These comprise about 2,2 miles of road selected by the State highway co mission for improvement under their direction wi funds provided by the State and local government The State highway department executes all survey prepares plans and estimates, and supervises t construction for all roads of this group. The co of the work, exclusive of the cost of right of way, borne as follows: In all counties or districts havi an assessed valuation of $1,000,000 or more, t State pays one-third of the cost and the county district pays the remainder. In districts of less th

$1,000,000 valuation the cost is shared equally by the State and county or district. When completed the road is maintained by the State or the commission may arrange with the county or district to execute naintenance.

Initiative for improvement of roads of this group s taken by the county or district board which nakes application to the State highway commission or State assistance. If deemed feasible and funds herefor are available, the necessary preliminary vork is executed by the State highway department. The plans and specifications are approved by the State highway engineer and the local boards concerned, and when the estimated cost exceeds $2,000, he work is let by contract or with the consent of the oard of prison commissioners and warden of the enitentiary, State convicts may be employed by he State highway commission to execute the work. f done by contract, contracts are let by the State ighway commission and a resident engineer is letailed to take charge of the work during its progess. He prepares monthly estimates covering 85 er cent of the completed work and these estimates vhen approved by the local boards, the State highvay engineer, and the State board of examiners, are aid by the State treasurer. Final payment is made n a similar manner.

County roads.—All other public roads of the tate are classed as county roads and are located, ontrolled, constructed, and maintained by county r district boards with local funds. The State highvay department exercises no authority over roads f this group, but may advise local officials relative hereto at their request. County prisoners may be equired by order of the county board to labor on ublic highways.

REVENUES.

State.—The State highway fund is composed of he remainder of the proceeds of the State bond ssue of $1,000,000, or about $500,000, 22½ per cent f the revenues accruing from the registration of notor vehicles and 22½ per cent of all fines and enalties accruing from violation of the motor ehicle act. This fund is available for the support f the State highway department and for the conruction and maintenance of State highways. It estimated that State's portion of the motor vehicle und will amount to about $98,000 for the calendar ear 1918. Two and one-half per cent of the revenues om motor-vehicle registration and a State highway x of one-tenth of 1 mill upon the assessed value property within the State are placed on redemption unds for the payment of the principal and interest State highway bonds.

County.—County road and bridge funds are otained from the imposition of a cash poll tax vied at a rate not exceeding $4 per year on each able-bodied adult male person between the ages of 21 and 50 years. Seventy-five per cent of the amount collected within the borders of incorporated cities, towns, and villages is returned to the road fund of the corporation. Seventy-five per cent of the auto revenues originating in each county are returned to the counties and districts for road improvement purposes. It is estimated that about $300,000 will be distributed by State authorities for the calendar year 1918. Property taxes at a rate not exceeding $1 on each $100 of assessed valuation may be levied by counties or district boards. The county board is entitled to receive 25 per cent of the funds raised by ordinary taxation in a highway district.

BONDS.

Bonds of the sinking-fund type may be issued by the State at a rate of interest not exceeding 4½ per cent for a term not exceeding 20 years. Similar bonds may be issued by a good-roads district at a rate not exceeding 6 per cent for a term not exceeding 20 years. Highway districts may issue bonds of similar type at the same rate of interest for a term not exceeding 10 years.

INDIANA.[1]

DEVELOPMENT.

State supervision over and participation in road improvement in Indiana has recently become a fixed State policy as the legislature in 1917 provided for the establishment of a State highway commission, for the designation of a State-wide system of main market roads to be improved at State and county expense, and for the extension of the supervisory and advisory powers of the commission to other roads of the State on request of the local officials in charge thereof.

The system of main market roads is at present limited to a mileage of 2,000, but after January 1, 1920, may be increased by the State highway commission with the approval of the governor of the State.

Prior to the passage of the legislation above referred to, road construction and maintenance in Indiana was vested in 1,017 township and 92 county boards. Under this form of organization about 31,000 miles or 42.5 per cent of the total road mileage of the State, had been surfaced, gravel and water-bound macadam being the most popular types of construction. However, as financing of road improvements by means of bond issues has been the almost universal practice and as the types of road constructed are ill suited to present-day traffic needs, it became necessary, in order to provide for economical reconstruction and maintenance of roads in actual use, to place trained technical men in supervisory and advisory charge of this work rather than to depend, as had been done in the past, on local officials elected by popular vote.

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[1] The constitution of the State highway law is now being tested in the supreme court of the State.

Local control of road work reached a higher state of development in Indiana than in most States and produced a system of surfaced roads which, under traffic conditions prevalent 20 years ago, would have been eminently satisfactory to the public. However, new traffic conditions have required different administrative measures and in the future action of town supervisors will be confined to roads of lesser traffic, leaving the more important roads under the charge of county and State officials.

The extent to which bonds have been issued for road and bridge improvements is evidenced by the statement that on January 1, 1915, $5,137,671.12 of county bonds and $36,957,686.22 of township bonds were outstanding.

The expenditures by all local forces of the State in 1917 for road and bridge purposes reached a total of $14,014,000.

ORGANIZATION.

The organization of the highway forces of the State and the relation existing between them is shown by chart on page 37.

State.—The State highway commission, a bipartisan body composed of four members appointed by the governor for terms of four years each, one member being chosen from each of the four districts into which the State has been divided by legislative enactment, is the administrative body in charge of the road work of the State. The State highway engineer, required to be a competent and skilled civil engineer, is selected by the commission and serves at their pleasure. He is the secretary of the commission and serves as their executive officer in the enforcement of State and bridge laws and the rules and regulations of the commission. Such technical and clerical force as may be required is employed by him with the approval of the State highway commission.

The State highway commission is required to select a system of main market roads, to cause to be prepared plans, specifications, estimates of cost of proposed improvements, and to enter into contracts for and to furnish competent supervision during the progress of the improvements. The State highway engineer, on request of 50 or more interested property owners, is required to inspect plans, specifications, estimates of cost, etc., of any road costing $2,000 or more per mile or of any bridge costing $500 or more, and the work may not proceed without his approval. The State highway department in general is vested with broad powers over the construction and maintenance of the main market roa system.

County.—Road administration in the county i vested in a board of three commissioners, one bein elected each year. The county auditor and count treasurer are respectively clerk and fiscal agent c the board. The board cooperates with the Stat highway commission in the improvement of th main market roads of the county and appoints for term of two years a county highway superintenden who has charge of the maintenance of the improve county roads. He may appoint an assistant supe intendent for each 25 miles of road under his car The county surveyor is ex officio engineer of th county or in case of his inability to execute and t supervise engineering work the board may appoin an engineer.

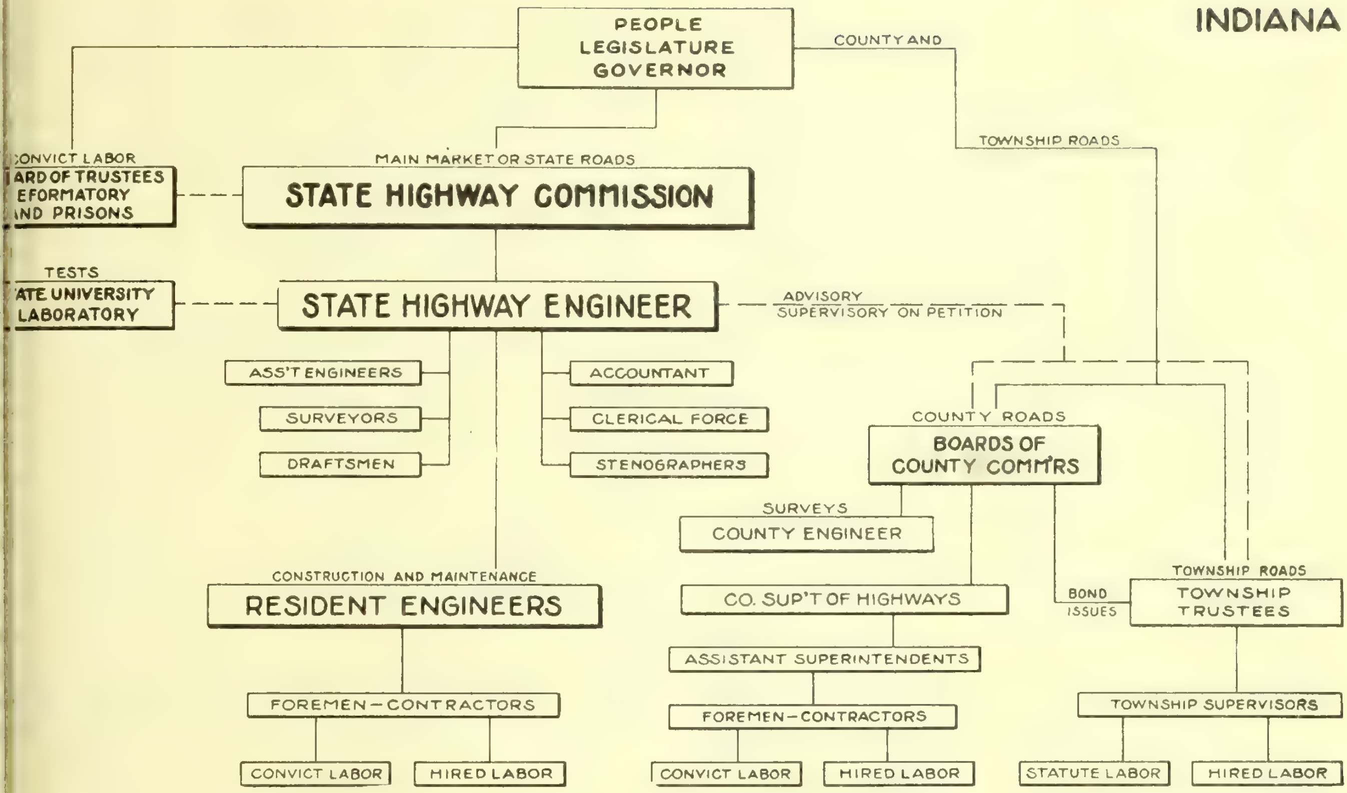
Township.—The township trustee, elected for term of four years, has general charge of the roa affairs of the township. He is assisted by supe visors elected for a term of two years by the vote of each district into which each township is divide

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 73,347 miles of public road in Indiana are f the purpose of fixing responsibility for constructio maintenance, and control divided into three group namely, main market highways, or State road county roads, and township roads. Of this syste of main market highways, limited to a mileage 2,000 until January 1, 1920, 800 miles connecti the principal centers of population of the State, h been designated by the State highway commissio and will be constructed under supervision of the co mission with Federal, State, and county funds.

Initiative for construction or reconstruction roads of this group is taken by the county boa which makes application to the commission f State aid, defines in a general way the extent of t project and agrees to provide sufficient funds to p the county's share of the total cost. On approv of the project by the commission, the State highw engineer causes to be prepared surveys, plans, spe fications, and estimates of cost for at least two typ or kinds of construction. Bids on both types a requested by the county board through notic published in two newspapers of different politic faith in the county. The county board after co sideration of the bids selects one of the two typ and with the approval of the State highway engine lets the contract. In case of disagreement betwe the State highway engineer and the county boa over the contract, the power to render a final de sion, after five days, lies with the State highw commission. Bridges costing more than $500 a let under separate contract. Road improveme

INDIANA



osting less than $1,000 may, at the discretion of e State highway engineer, be executed by force count labor. The work during progress is under e supervision of the State highway engineer or his presentative. Partial payment may be made by e State treasurer when approved by the State ditor at monthly intervals when based on esti- ates approved by the State highway engineer. inal payment is made in a similar manner on com- etion and acceptance of the work by the State ghway engineer. The amount of cost to be borne the county, 50 per cent or more, is certified by e State highway engineer to the county board for yment. All payments accruing from this source e deposited with and become a part of the State ghway fund. Roads of this group are maintained the State highway department at State expense. ate convicts, with the approval by the governor arrangements between the authorities having arge thereof and the State highway commission, may utilized in the preparation of road-building material.

County roads.—The county roads comprise those hich have been improved at township expense and e maintained by and at the expense of the county.

Township roads.—These may be improved and rfaced on petition to a county board of 50 free- lders resident of the township or townships fected. In special cases involving the construc- on of 3 miles or less of road which has termini ecified by law, the county board may order the ork done without submitting the proposal to the ters of the territory affected. Otherwise an election is held to secure an expression of public sentiment and to authorize the issue of the necessary township bonds. The work during progress is under supervision of the county boards and such engineering force as they may select. However, on petition of 50 or more interested freeholders, the State highway engineer is required to inspect the plans and specifications and may require changes therein, or, if requested, he may detail at township expense a competent subordinate to take charge of the work. Surfaced roads of this group are transferred to group 2 for control and maintenance. The remaining roads of this group are maintained by township forces at township expense. The work done under this head consists principally of minor repairs in grading and such general maintenance as is usually done by district or township officials.

REVENUES.

The State highway fund is composed of (*a*) proceeds of the inheritance tax paid after April 1, 1917, (*b*) receipts from public-service corporations on account of the elimination of grade crossings, (*c*) reimbursement by counties as their share of construction, (*d*) appropriation by the State legislature, (*e*) all unexpended balances remaining in the fund at the close of a fiscal year. For 1918 approximately $1,050,000 will be available, of which $600,000 will be derived from appropriation and $450,000 from the inheritance tax.

From this fund are deducted sums necessary to support and maintain the State highway department and provide for the maintenance of the system of main market roads, and the remainder is apportioned among the counties of the State in the proportion that their main market road mileage bears to the total road mileage of the system.

County.—The motor-vehicle fund is apportioned by the secretary of state among the counties as follows: One-third equally among the counties, one-third in proportion to the miles of free gravel or macadam road in the county, and one-third in the ratio of each county's contribution to the motor-vehicle fund. Counties may levy a tax at a rate of not to exceed 1 cent on $100 valuation for maintenance of free improved roads.

Township.—A tax at a rate not exceeding 30 cents on each $100 of valuation may be levied for road and bridge purposes. Up to 20 cents of this tax may be worked out on the township roads, providing that an additional tax paid in cash of 10 cents on each $100 valuation be levied for road and bridge purposes.

Bonds.—Serial bonds in an amount not exceeding 4 per cent of the assessed valuation of the county or township may be issued for road and bridge purposes. Such bonds bear a rate of interest not to exceed 4½ per cent and are generally limited to a term of 20 years.

IOWA.

Development.—State interest in and supervision over road and bridge improvement in Iowa has developed from the organization in 1904 of several members of the faculty of the Iowa State College at Ames as a State highway commission with advisory and research powers to a State highway department provided with limited state-wide powers over all road and bridge work in the State, and with full powers over a fund to assist the various counties in constructing permanent improvements on a specified system of roads.

The work instituted in 1904 by the State College was amplified in 1913 by the creation of an independent highway commission of three members, one of whom was the dean of engineering at the State college with increased advisory duties and a more liberal appropriation for its support.

As the State did not provide funds for road and bridge construction until 1917, practically all improvements have been financed and executed by the counties of the State, generally in accordance with plans approved by the State highway commission.

The legislation of 1917 provided for the selection of rural post roads with a total mileage of not less than 2,000 nor more than 6,000, to include a part of the road mileage of each county as a road system to be improved under State supervision at State and county expense.

Statistics available at the close of 1916 show tha about 1,000 miles, or approximately 1 per cent o the total road mileage of the State, had been surfaced

Expenditures for road and bridge purposes durin the year 1916 were as follows: By the State highwa commission for its support and operation, $90,821 and $14,337,056 by the local officials under the mor or less general supervision of the State highwa commission.

A large percentage of the above sum was expended for the construction of bridges and culvert of permanent type and the greater portion of th remainder of the sum was spent on drainage, grading and dragging of earth roads, leaving a comparativel small sum expended for permanent surfacing Thus the present road system of Iowa consists almos entirely of earth roads.

Iowa has a large road mileage and is not willing a present to bear the financial burden required t provide surfacing for the present road system However, the necessary preliminary work for system of good roads is being executed and surfacing may be added when permitted by financia conditions.

ORGANIZATION.

The organization of the highway forces, State an local, and the relation existing between them i shown on page 39.

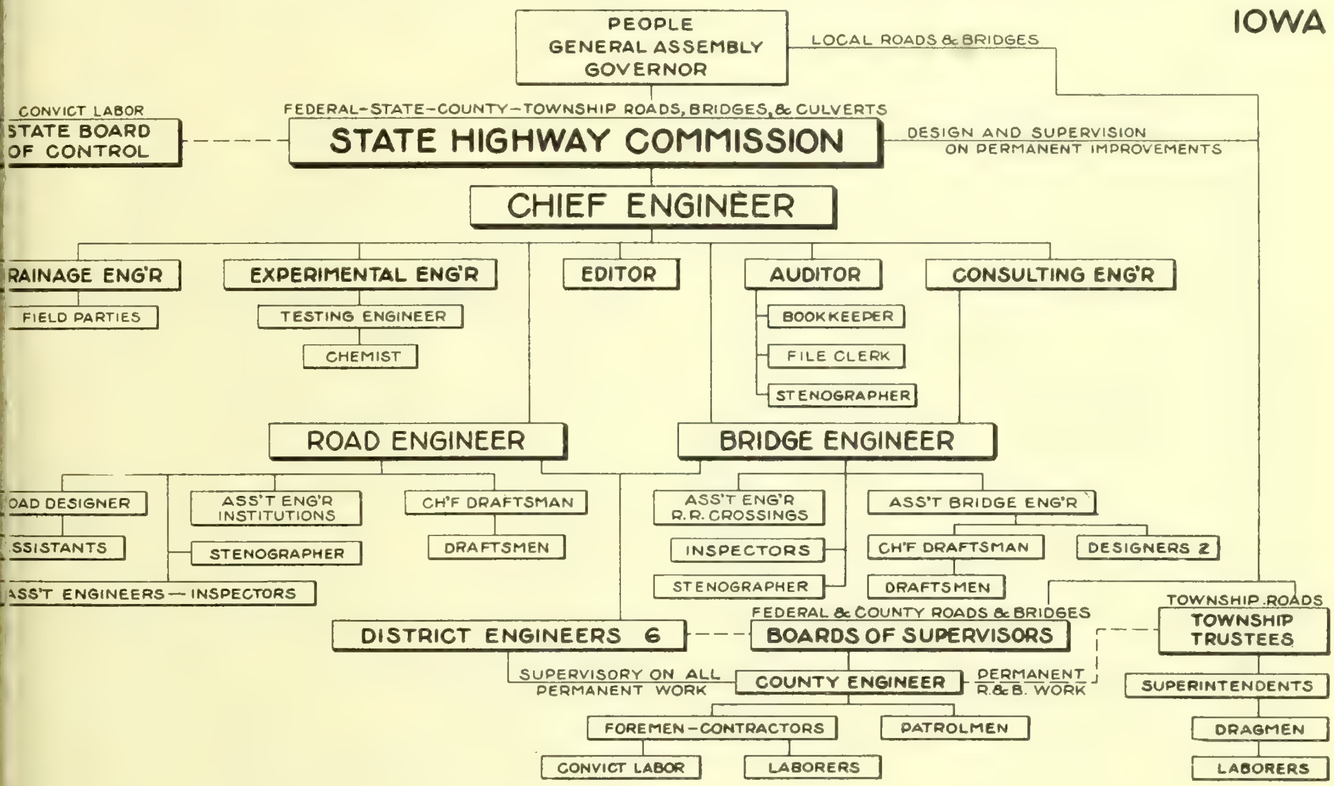
State.—The administrative head of the roa and bridge forces of the State is a State highwa commission composed of the dean of engineering o the Iowa State College and two members of differen political faith appointed by the governor for term of four years each.

The commission is empowered to select the road upon which Federal or State funds are expended, t supervise such expenditures, and to exercise genera supervision over all road and bridge work throughou the State. All county and township road official are subject to supervision and inspection by th State highway commission and may at the initiativ of the commission be removed from office for negligence of duty or improper or unlawful conduct o their office.

The commission, in cooperation with the Iow Railroad Commission, has the power to mak agreements with railroad companies for the elimination of dangerous grade crossings and may defray on behalf of the State, a portion of the cost of suc work.

The commission has the power to employ and fi the compensation of such employees as may b necessary to carry out the duties imposed upo them by law. The chief engineer appointed by th commission serves as their executive official i charge of the force employed by the commission and is represented in various sections of the State b five division engineers.

County.—The board of supervisors, consisting generally of three members elected for terms of three years, comprises the body in charge of county road and bridge work. The number of supervisors nay be increased to five or seven by a majority vote of the county. The county auditor and the county treasurer are respectively clerk and fiscal agent of the board. The county engineer is selected by the board for a term of office not to exceed one year. He serves under the direction of the board but the State highway commission exercises extensive jurisdiction over the technical part of his duties.



Township.—Road affairs are administered by board of directing trustees. The township clerk s clerk of this board. The board appoints at least ne and not more than four township road superin-endents to have charge of the road construction nd repair, and to execute or supervise the dragging f township roads required by law.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 104,074 miles of public road in Iowa are ivided for the purpose of fixing responsibility for control into three groups, namely, systems of intercounty roads, county highways, and township roads.

Intercounty roads are selected by the State ighway commission from roads recommended by the county board of supervisors of each county. hey are required to be important routes of travel nd are selected to form as nearly as practicable a tate-wide system. The present mileage of this system is restricted by statute to 6,000.

Roads of this group are constructed by the county under the direction of the State highway commission, the cost being borne by the State and Federal Governments from a fund known as Federal-county cooperation road fund. The county contributes whatever additional amount it is possible to divert to such work from regular road levies. All rights of way are secured and all bridges and culverts are constructed at the expense of the county. Initiative in construction is taken by the county board, which requests an allotment of funds for a specified project and contracts with the State highway commission to provide proper maintenance therefor when the road is constructed. Surveys are made by the county engineer or a representative of the chief engineer of the commission. Final plans and specifications are approved by the county board, the State highway commission, and the United States Secretary of Agriculture. Bids are requested by the county board; and contracts are let by the board with the approval of the State highway commission. The successful bidder files a bond acceptable to the county board and to the State highway commission. The work during progress is generally under the charge of the county engineer or, if it is deemed advisable, an engineer is detailed by the chief engineer of the commission to assist or take full charge of the work.

Monthly payments based on estimates prepared by the engineer in charge and certified to by the contractor are made with the approval of the county board and the State highway commission.

Payment is completed by the presentation of a voucher by the State Highway Commission to the State auditor who issues a warrant on the State treasurer.

Maintenance of the completed roads is executed by and at the expense of the county in accordance with the orders and subject to the inspection of the State Highway Commission.

County roads.—Each county board of the State has been required to designate and to indicate on the map not less than 10 per cent nor more than 15 per cent of the total road mileage of the county. This group of roads when approved by the State highway commission is known as the county road system and is constructed and maintained by county officials with county funds in accordance with plans and specifications approved by the State highway commission. The county system as evidenced by the map approved by the State highway commission and and filed with the county auditor may be modified or extended by the county board with the approval of the State highway commission. Improvement of these roads may be done by contract, by force account, or with convict labor from the State penitentiaries, under supervision of the State highway commission. All bridges and culverts constructed on roads of this group must be erected in accordance with plans furnished by the State highway commission, and all contracts involving the expenditure of $2,000 or more must be approved by the State highway commission. By the terms of a law effective July 4, 1917, the patrol system of maintenance became obligatory on the county systems of highways. Patrolmen are required to give their entire time for the period specified by the county board of supervisors.

The total mileage of county roads is restricted at present by statute to 15,667 miles.

Township roads.—All other public roads of the State not included in the county system comprise the township roads administered by township officials. All work other than minor or emergency repairs and routine dragging done on these roads is executed under supervision of the township officials in accordance with plans and specifications prepared by the county engineer.

REVENUES.

State.—The State treasurer is authorized to withdraw each year from the fund accruing from the registration and licensing of motor vehicles, (1) 5 per cent of the gross receipts for the support of the State highway commission, (2) 5 per cent for the office of the secretary of State to defray the cost of collection, (3) an amount equal to the amount of Federal aid allotted that year to the State by the United States Secretary of Agriculture. This fun combined with the Federal aid forms the Federal county cooperation fund which is allotted to th several counties of the State in the ratio that thei area bears to the total area of the State. (4) A further deduction from the motor-vehicle fund by a amount specified by the highway commission i made by the treasurer and credited to a fund designated the "Federal aid engineering fund," out o which the engineering expense incurred by th State highway commission in improving the intercounty road system is defrayed. The amounts available for the year July 1, 1917, to June 30, 1918, ar estimated to be as follows:

Fund 1	$105,000.00
Fund 2	105,000.00
Fund 3	438,526.80
Fund 4	30,000.00

County.—The remainder of the motor-vehicl fund is apportioned by the State treasurer amon the several counties of the State in the ratio tha the number of civil townships in each county bear to the total number of townships in the State. No to exceed 10 per cent of the amount apportioned t each county is apportioned by the county treasure among the incorporated cities and towns in the rati that their street mileage bears to the total roa mileage of the county. This fund may be expende by cities or towns in improving streets, connectin with county or township roads, or the fund may b transferred to the county cash road fund for expenditure by the board of supervisors.

The county cash road fund is composed (1) of th proceeds of not to exceed 1 mill tax levied on a taxable property in the county. One-half of th amount raised in cities or towns is returned to th city or town for use on its main streets or road (2) a 2-mill tax levied on all taxable property outside incorporated cities and towns, and (3) a m tax levied in cities and towns except cities of th third class and cities having a special charter.

The county road and bridge fund is composed of tax levied at a rate which may not exceed 5 mil on all taxable property in the county outside citi of the first class.

Township.—The township road fund is composed of the proceeds of a tax levied at a rate n exceeding 4 mills on all taxable property in th township. The township drag fund is raised by a ta of 1 mill. The township drainage fund is raised b a tax of not more than 5 mills. This fund is raise for the payment of benefits assessed against th township on account of the improvement of highways by the formation of drainage districts.

A special tax at a rate of 1 mill may be levied f road purposes on petition of a majority of the vote of the township.

All able-bodied males, not legally exempt, resident in the township, between the ages of 21 and 45, are required to labor two days each year on the township roads or to forfeit $3 for each day's delinquency.

BONDS.

Bonds may be issued by the county boards of supervisors to refund outstanding warrants for which no funds are available. The amount of bonds issued, the term, and rate of interest is left to the discretion of the various county boards. Such indebtedness is limited by State law to 5 per cent of the total assessed valuation of the county. County bonds in the amount of $1,960,780 were outstanding on January 1, 1915.

KANSAS.

Development.—The State government of Kansas is prohibited by a clause of the State constitution rom assisting in any work of internal improvement. However, this restriction has been construed by the State courts to refer to the grant of money aid for he work of internal improvement and does not prohibit the delegation of authority to county officials to carry out such improvement nor prohibit State officials from giving advice relative to or preparing plans and specifications for such work and actually supervising the construction and maintenance thereof.

Supervision of road and bridge matters prior to 917 was vested in the officials of 105 counties and ,492 townships. The results obtained under this orm of administration were a prominent factor in bringing about a State-wide demand for a competent entralized supervisory and advisory road and bridge uthority. In deference to this demand the State egislature in 1911 provided that the State engineer f roads and highways at the State Agricultural College should furnish, free of charge, technical or ther advice to all local road and bridge officials pplying therefor.

In 1917 legislation was enacted creating a State ighway commission with limited State-wide jurisiction over certain groups of roads and supervisory owers to a limited degree over all road and bridge work in the nature of substantial improvements made throughout the State. The county systems comprising the main traveled roads of each county ave been selected for improvement under the irection of the commissioner, and these systems ave been selected to form a network of roads conecting all of the principal towns of the State.

Kansas has a road mileage of 111,052, of which at he close of 1916, 1,400 miles, or 1.3 per cent, had been surfaced, although many miles of earth roads had been graded and drained. The expenditures for road and bridge work during the year 1916 comprised $10,000 expended by the State highway department for educational and supervisory work, and $5,610,000 expended by local officials subject to supervision by the State highway department as was requested by the local officials in charge of the work. The total State and local expenditure during 1917 amounted to $6,010,000.

With the organization of the State highway commission and the allotment of Federal funds to a system of 3,440 miles of main highways and the supervision of Federal aid projects by the commission, the influence of capable centralized authority will be manifested in better types of improvement, more attention to maintenance, and a greater popular demand for an increased mileage of good roads.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on page 42.

State.—The State highway commission, composed of the Governor and two members appointed by him for terms of four years each, has power to employ, remove, define the duties and fix the compensation of such employees as may be necessary to carry out the duties imposed by law. It has general supervision over the administration of all State road and bridge laws, and over the construction and maintenance of all roads, bridges, and culverts throughout the State except the administration of township roads not in receipt of Federal aid.

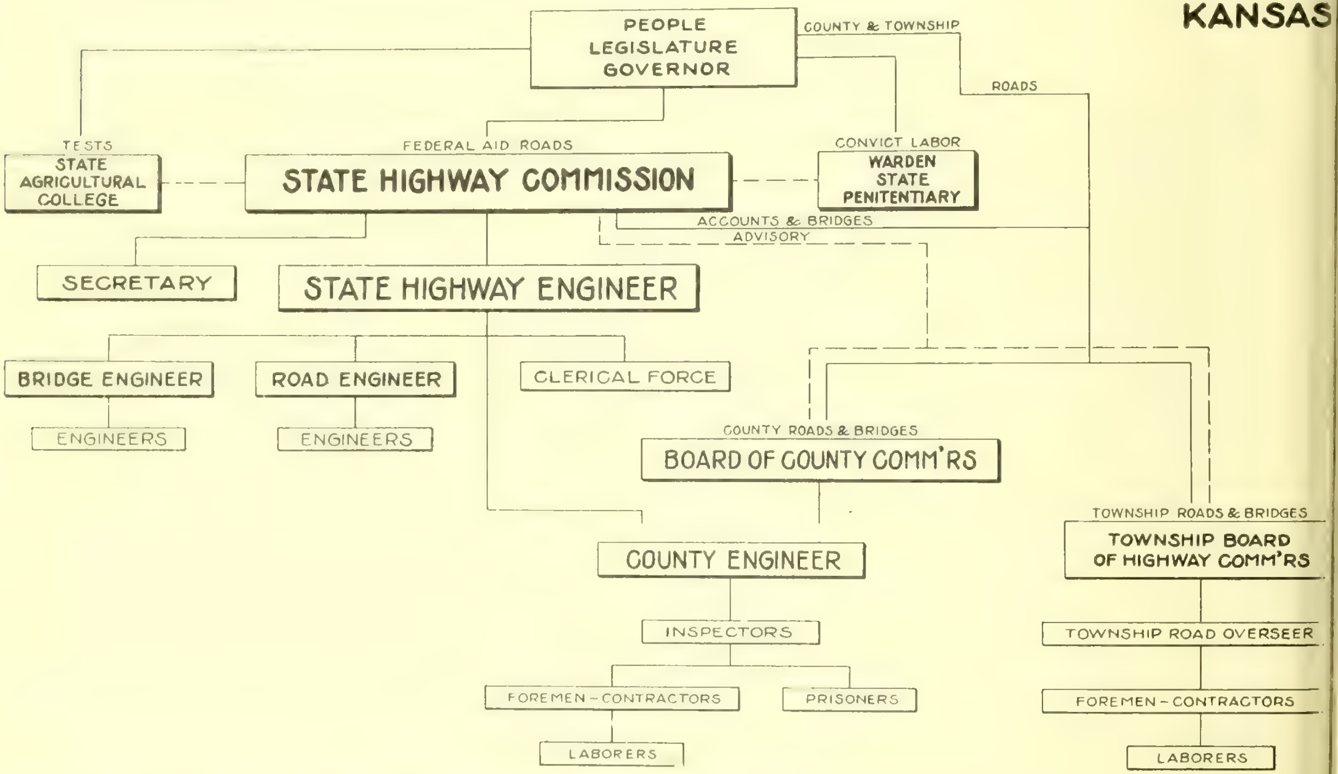
The commission is required to establish and furnish to the several county engineers plans and specifications for all road, bridge, and culvert construction in the State; to reply to all inquiries from local road officials relative to road and bridge matters; to require reports on standard forms from all county and township road officials; to devise a uniform system of auditing and accounting, and enforce its use by all county and township fiscal officials engaged in road and bridge work.

The commission is empowered to act as agent for the several counties in negotiations conducted with the United States Secretary of Agriculture in matters relating to allotment of Federal funds.

The State highway engineer, the executive official of the commission, is chosen by them and serves at their pleasure.

County.—County road and bridge affairs are administered by a board of three commissioners elected for terms of four years each. The county clerk and county treasurer, elective officials, are respectively the clerk and fiscal agent of the board. The county engineer, selected by the board with the approval of the State highway commission for a term of two years, is their executive official in all road and bridge matters. He is subject to the rules and regulations issued by the State highway commission relative to road and bridge matters, and may be removed from office by the county commissioner for cause or by the State highway commission for incompetency. In addition to his other duties, he acts in a supervisory and advisory capacity with township road and bridge officials.

Township.—The board of township highway commissioners composed of the town trustee, clerk, and treasurer, each elected for a term of two years, has charge of all work in the township financed with township funds. The board is required to appoint a township road overseer and may, if the county engineer deems it necessary, provide him with suitable assistants.



CLASSIFICATION, CONTROL, AND PROCEDURE.

The 111,052 miles of public road in Kansas are by law divided into county and township roads.

County Roads.—The county board of each county is required to select, with the approval of the State highway engineer, not less than 50 miles nor more than 15 per cent of their total road mileage as a road system to be improved by the county in accordance with plans and specifications approved by the State highway engineer. When the total mileage selected in a county has been improved, additional roads may, with the approval of the commission, be added to the system. On January 1, 1918, 3,440 miles of road had been selected and approved.

Township Roads.—All roads of the State not included in the preceding system are classed as township roads and are improved and maintained by township officials with township funds. All contracts let by township boards for construction which exceed $200 in amount and all contracts for purchases of machinery exceeding $100 in amount require the approval of the county engineer.

Roads of either group may be improved by order of the governing board or improvements may be initiated on petition of 51 per cent of the owners of 35 per cent of the land abutting on the road in question, or 35 per cent of the landowners owning 51 per cent of the land or by the owners of 60 per cent of the land within a given district. The petition is addressed to and filed with the county board. The board after finding it to be a public utility orders plans, specifications, and estimates of cost of the improvement to be prepared by the county engineer or the State highway engineer. The plans must be approved by the State highway engineer, and, if Federal aid is requested, by the United States Secretary of Agriculture.

The work may be done by prison labor with the approval of the warden of the State penitentiary, by force account under the direction of the county engineer, or by contract let by the county board in the manner prescribed by statute. The work during progress is under the supervision of the county engineer and is subject to inspection by the State highway engineer.

Partial payments covering 70 per cent of the completed work may be made by the county board when based on an estimate prepared and approved by the engineer in charge and by the State highway engineer if Federal funds are involved. The road when completed is maintained by the county at county expense. The State highway commission is required to inspect or cause to be inspected yearly all roads financed in part with Federal funds; to inform the county commissioners of the repairs needed, if any, and to require the county board to make the repairs. The total cost of the road is borne as follows: All bridges costing more than $2,000 and all bridges of 20-foot or more span are paid for by the county. From the remainder of the cost the Federal allotment, if any, is deducted and the balance of the cost is apportioned 50 per cent to the county, 25 per cent to the township or townships, and 25 per cent among the landowners adjoining or adjacent to the road so improved.

The county board may under certain conditions assume 60 per cent of the remaining cost, leaving 15 per cent to be borne by the landowners.

If more than 30 miles of road are involved and a majority of the legal voters of the county so approve, the total cost of the work less Federal aid extended, if any, may be borne by the county as a whole.

REVENUES.

State.—An appropriation of $25,000 per year for the support of the State highway commission is made by the State legislature. No other State funds are provided for road and bridge work either directly or indirectly.

County.—Federal funds allotted to the State are apportioned equally among the several counties conditioned on the county providing $85 for each $15 allotted, and further provided that the total sum shall be expended in accordance with the rules and regulations of the United States Secretary of Agriculture.

A road tax at a rate of not less than one-fourth mill nor greater than 1½ mills may be levied by the county board for the construction and maintenance of the county road system. A tax rate greater than 1½ mills may, if authorized by a majority vote of the legal voters of the county, be levied by the board. Fifty per cent of the net receipts collected in each county for the registration of motor vehicles is placed in the county road fund.

Township.—A tax at a rate of not to exceed 3 mills may be levied by the county board on favorable recommendation of the township board. Taxes at a rate greater than 3 mills may be levied whenever authorized by a majority of the voters of the township. All male inhabitants between the ages of 21 and 50 are required to pay a poll tax of $3, or in lieu thereof to labor two days on the public roads. Poll tax collected in cities is refunded to the city treasury.

Fifty per cent of the net receipts collected in each county for the registration of motor vehicles is returned to the townships in which the owners reside, and placed to the credit of the township road fund.

BONDS.

Serial bonds of not less than 10 nor more than 20 years' term, bearing not to exceed 5 per cent interest, may be issued by county boards to finance road and bridge improvement when authorized by a majority vote of the county or of a special district, as the case may be.

KENTUCKY.

Development.—State participation in road and bridge improvement in Kentucky began in 1821 and by 1837 the State had invested $2,509,473 in an improved road system, of which 343 miles had been constructed of macadam and 236 miles were under construction, and a large number of earth roads had been graded and drained. This work was under the supervision and control of a State highway engineer who received a salary of $5,000 per year, and who was assisted by a well-paid force of competent men. State aid was from this date diminished and finally discontinued prior to the Civil War and remained inactive until revived in principle by the appointment in 1912 by a State commissioner of public roads with educational and advisory duties.

In 1914, authority for the selection and designation of a State highway system and a fund for assistance in its construction under the supervision of the State commissioner of public roads was provided by the legislature.

Due in great part to the substantial nature of the roads constructed in early days under State supervision, public interest in road improvement did not entirely lapse with the discontinuance of State assistance, and at the resumption of State aid in 1914, 10,663.5 miles or 18.4 per cent of the entire road mileage of the State had been surfaced and were in fair condition; limestone, macadam, and gravel being the principal materials used.

Under the present law, State aid is extended to assist the counties in the construction of the State system of roads. This system when completed will have a mileage of about 8,000, or 13 per cent of the total mileage of the State. On January 1, 1917, 1,611 miles of road of this group had been improved or reconstructed while 13,400 miles, or 23.2 per cent of the total road mileage of the State had been surfaced.

The State highway commissioner in addition to the supervision of the expenditure of State funds also on request of local officials exercises supervision over projects financed with local funds. During 1916, $708,346 of State funds and $1,740,187 of local funds were expended by or under his supervision. The total $2,448,553 comprises 55½ per cent of $4,448,553, the total expenditure by all road and bridge forces of the State during the same period. The total expenditure from all sources during 1917 amounted to $4,923,651.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on page 45.

State.—The department of public roads is headed and administered by a State commissioner of public roads appointed by the Governor for a term of four years. He is required to be at least 25 years of age, a graduate civil engineer from some reputable university or technical college and shall have had five years experience in civil engineering. All road and bridge work in the State financed wholly or in part with Federal or State funds, or constructed by State convict labor is under the general supervision of, and must be completed in accordance with the plans and specifications approved by, the commissioner.

Engineering and technical assistants necessary to carry out the duties of the department are selected by the commissioner with the approval of the governor. The State, for administrative purposes, is divided into 11 divisions, each in charge of a division engineer who consults with and tenders advice to county road officials, and who has supervisory charge of State and Federal aid construction.

County.—County road and bridge affairs are as a rule administered in the 120 counties by fiscal courts composed of the county judge and a magistrate from each magisterial district of the county. There are a few counties in which road affairs are administered by three or more commissioners who are elected by the people. All of the above officials are elected for terms of four years. The county clerk is clerk to the governing body and the county treasurer is fiscal agent.

The governing body of the county may appoint as county engineer one who is required to be either a reputable civil engineer or a man who has had two years practical experience as a road builder and who shall have passed an examination held by the State commissioner or his representative. He serves as the executive official of the county in all road and bridge matters and receives general instructions from the State commissioner relative to standards and types of construction, gradients, etc., of all public roads and for plans for all bridges costing $500 or more.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 57,916 miles of public road in Kentucky are divided, for the purpose of fixing responsibility for construction, control, and maintenance, into two general groups, namely, State-aid highways and county roads.

State-Aid Highways.—At present these comprise a system of intercounty-seat highways selected by the governing bodies of the respective counties with the approval of the State commissioner of public roads. This system comprises about 8,000 miles of road connecting county seats constructed under State supervision at the joint expense of the State and county. Of this system about 2,000 miles had been completed or under contract on January 1, 1918. State aid is at present restricted to roads of this group. However, on completion of the present mileage additions may be made to the system by agreement between the county boards and the State commissioner.

Initiative for improvement of roads of this group is taken by the fiscal town or county board. The resolution of the court or board is transmitted to the State commissioner of public roads for his investigation and approval. If the project is deemed feasible, within the extent of the law and the necessary funds are available, the surveys, plans, specifications, and estimates are prepared by the State highway department, the cost being paid one-half by the State and one-half by the county. Construction may be executed by State convict labor, operating under the direction of the commissioner, or the county board may, after due publicity, let the work by contract, except on Federal-aid projects, which are let by the State highway department. All contracts for road and bridge work and all bonds filed by the contractors are required to bear the approval of the State commissioner of public roads.

The work during progress is under the general supervision of the State highway department, the county engineer, and the immediate supervision of an inspector appointed by the State commissioner. Monthly payments, covering 80 per cent of the completed work, may be authorized by the county board when supported by an estimate prepared and certified to by the inspector, and approved by the county engineer.

On completion and acceptance of the work and the presentation of certified statements of cost by the inspector and county engineer, the State commissioner orders the State auditor to draw a warrant against the State road fund in favor of the county. The State assumes 75 per cent of the cost of construction of intercounty-seat roads in counties whose assessed valuation is less than $5,000,000; 70 per cent of the cost in counties having an assessed valuation between $5,000,000 and $6,000,000; 65 per cent of the cost in counties having an assessed valuation between $6,000,000 and $8,000,000; 60 per cent of the cost in counties having an assessed valuation between $8,000,000 and $12,000,000; 55 per cent of the cost in counties having an assessed valuation between $12,000,000 and $16,000,000 and 50 per cent of the cost in all counties having an assessed valuation of $16,000,000 or more.

The State may pay in all counties 50 per cent of the cost of construction of roads added to the State-aid system but which are not intercounty-seat roads. All cost incident to the preparation of plans, surveys, inspection, etc., is considered a part of the total cost of the work, and is borne equally by the State and counties.

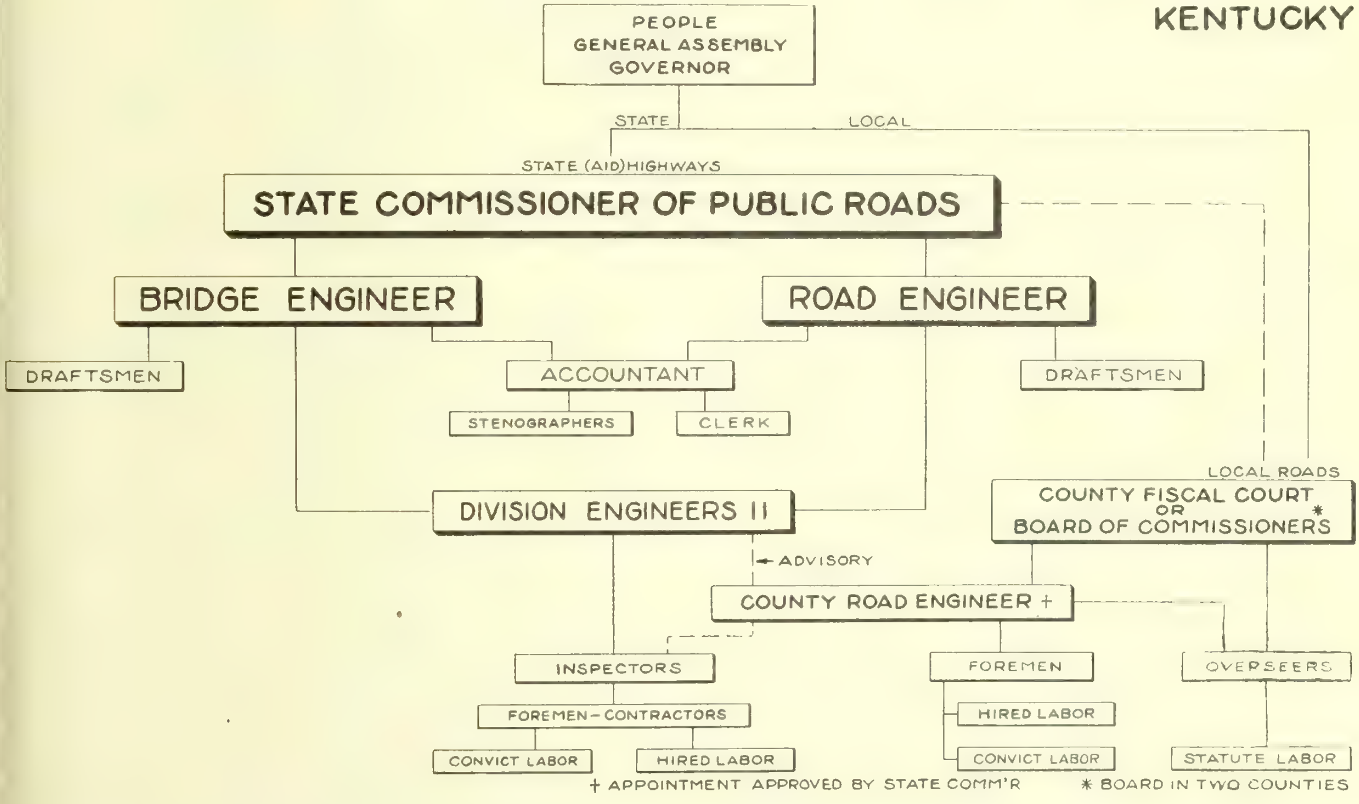
Roads of this group, when improved, are maintained by and at the expense of the county, but if the counties fail to maintain the roads, State aid may be withheld or State-aid funds apportioned to the county may be used by the commissioner in executing maintenance.

County Roads.—All other public roads of the State, with a total mileage of about 50,000, are included in this group. On January 1, 1917 about 12,000 miles, or 24 per cent of this system had been surfaced.

All expense incident to the construction, repair, and maintenance of these roads is borne by the county. County jail or workhouse labor, statutory labor, or force account labor may be used in their construction and repair, or the roads of the county may be divided into sections not exceeding 2 miles in length and sold for maintenance purposes for yearly periods to the lowest bidder.

REVENUES.

State.—The State road fund for aid to the State-aid system is apportioned among the various counties of the State applying therefor, in the ratio that the amounts collected in each county for road purposes, including the interest on bonded indebtedness incurred for road purposes and all donations bear to the total collection made by all counties. No county may receive more than 2 per cent of the fund in any one year, and counties expending an amount greater than the amount required to allow them to share in State aid may receive the difference as aid during the succeeding years without providing additional funds, provided that the allotment so received be expended for road work under the supervision of the State commissioner.



This fund is composed of revenues raised from the following sources, and it is estimated that during the calendar year 1918 the following amounts will be produced:

(1) A $\frac{3}{10}$ mill State-wide tax	$600,000
(2) Net receipts from motor-vehicle fees	300,000
(3) Whisky tax (one-eleventh of 10 cents on each gallon)	50,000
Total	950,000

An amount not exceeding $25,000 to defray the expenses of the State department of public roads is set aside from the State fund before making allotments to the counties.

County.—Current revenues are obtained from an ad valorem tax levied at a rate not to exceed 50 cents on each $100 of taxable property, one-half of which may be used for road purposes. A poll tax may be levied for road purposes on male inhabitants over 21 years of age at rates which vary in the different counties. These funds are expended by the fiscal court or other governing body for all county purposes, including road and bridge expense. Six days statutory labor on the roads may be required of all able-bodied male citizens between the ages of 18 and 45, but this tax is not generally observed.

The fiscal court may authorize counties to vote on an additional tax of 20 cents on the $100 valuation for road purposes.

BONDS.

Bonds for road and bridge purposes bearing not to exceed 5 per cent interest, payable semiannually, may be issued by the governing boards of counties for a term not less than 5 nor more than 30 years, when authorized by a majority vote of the electors of the county voting at a special election held for that purpose.

The proceeds of the bond issue are administered by the fiscal court, or by a board of commissioners appointed by the fiscal court or elected by the voters at the special election authorizing the bond issue.

The bonds may after five years be retired at the pleasure of the court, or board, or the sinking fund provided for their redemption may be invested in real estate mortgages. On January 1, 1915 there was outstanding a total of $705,000 of road and bridge bonds issued by the counties. Several counties have issued bonds since that date, and it is now estimated that there are outstanding $5,525,000 of road and bridge funds.

LOUISIANA.

Development.—State participation in highway improvement in Louisiana was first manifested in 1909 by cooperation between the board of State engineers, the board of control of the State penitentiary, and the police juries of various parishes in the supervision and use of State convicts for road-building purposes. In 1910 a State highway department was organized and the distribution of State aid in the form of money aid, use of convict labor, or machinery under the supervision of the State highway department was made a permanent State policy.

The State highway department is under the supervision of the board of State engineers, which has charge of all engineering work financed by the State. Prior to 1909 little permanent road improvement had been attempted throughout the State, but with the organization of the State highway forces and the dissemination of the correct principles of road building improvement in the condition of the road became apparent, and on January 1, 1917, 2,400 miles, or 9.8 per cent of the entire road mileage of the State, had been surfaced.

A State-wide system comprising about 5,000 miles of road connecting parish seats and important commercial centers has been selected by the State highway department for improvement by means of Federal, State, and parish funds under the supervision of the State highway department. On January 1, 1918, 752 miles, or 15 per cent of this system, had been improved.

The expenditures for road and bridge purposes during 1916 were $184,533 of State funds and $274,111 of local funds, expended by or under the supervision of the State highway department, and an additional amount of $3,000,000 of local funds expended by the police juries of the various parishes. State supervision thus extended to 13.9 per cent of the total expenditure. The total State and local expenditures during 1917 amounted to $3,540,976.

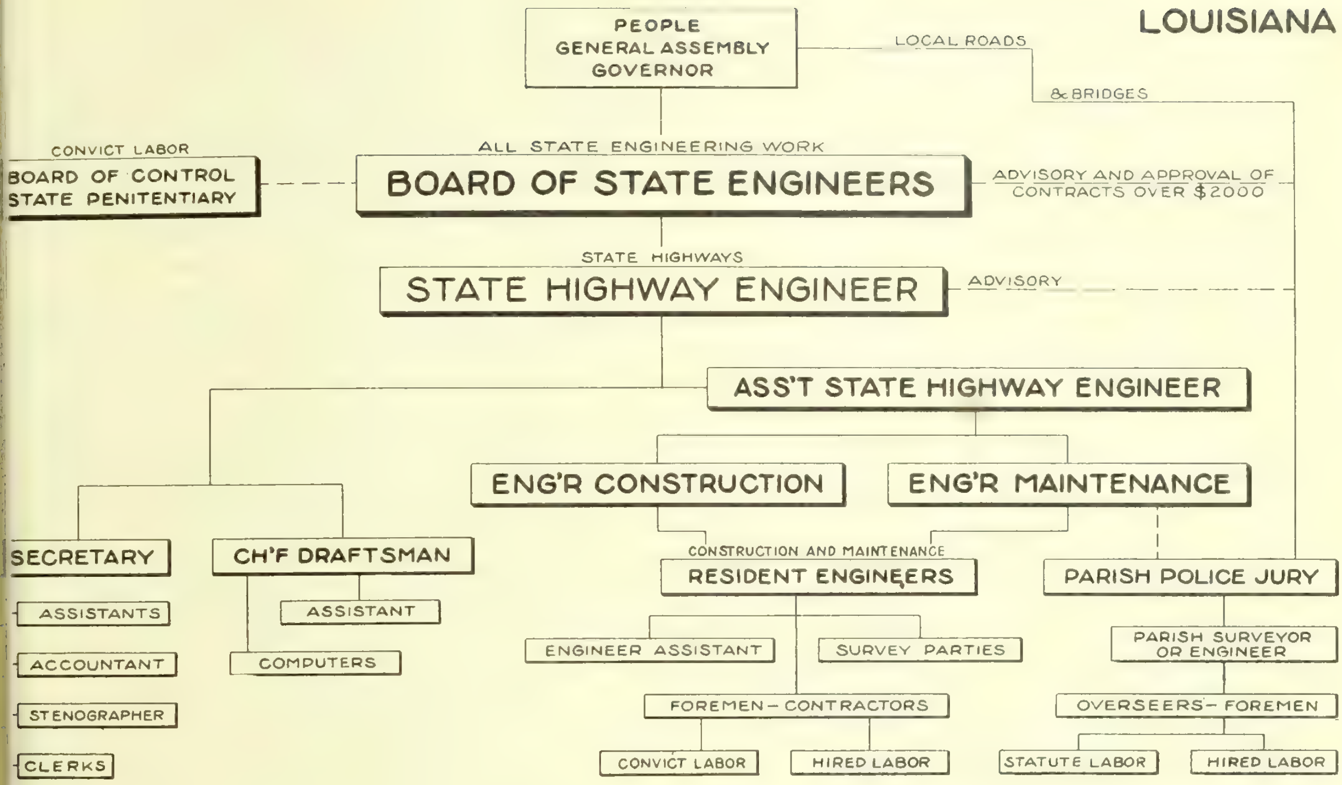
ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown in the accompanying diagram.

State.—The State highway engineer selected by the board of State engineers serves at its pleasure and is the executive official in charge of the State highway department. Such assistants as may be required by him are appointed by the board. The board of State engineers is required to consider all questions of general policy of the highway department and the conduct of its work and to bring to the attention of the governor of the State all matters pertinent to appropriations, new legislation, etc.

The State highway engnieer, subject to the general supervision of the board of State engineers, is vested with broad powers over the contributions made by the State for highway improvement, the standards of contruction of state work, and certain local work involving the expenditure of $2,000 or more, and the selection and designation of a system of state highways upon which State aid may be extended. He is required to extend advice and technical assistance to local officials on their request.

Parishes.—The parishes of Louisiana correspond in size, organization, and powers to the counties of



other States. Their affairs are administered by a police jury consisting of an elective member from each of the wards into which each parish is divided. The members elect one of their number as president and employ a nonmember as secretary. The parish treasurer is their fiscal officer. The parish surveyor, appointed by the governor, who is not required to be a civil engineer or a parish highway engineer, may on the order of the police jury be employed on local road work. The police jury has jurisdiction over all road and bridge work in the parish financed with local funds, may levy taxes, issue bonds, and in all respects is a body politic.

District.—The police juries of the several parishes may, in accordance with the statutory restrictions, divide their parishes into road districts. Such districts are governed by the police jury or by a road committee selected by it. All expenditures involving $2,000 or more in road and bridge work may not be made until the plans and specifications therefor have been approved by the board of State engineers. The districts may participate in State aid under the same terms as the parish, except that they deal through the police juries.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 24,563 miles of public road in Louisiana are, for the purpose of fixing responsibility for construction, control, and maintenance, divided into two groups, namely, State highways and parish roads.

State highways comprise about 5,000 miles of the principal roads of the State, selected by the State highway engineer on the approval of the board of State engineers, for improvement with State and local funds. Initiative for construction or improvement of a road of this group is taken by the police jury of the parish by making written application for aid to the State highway engineer. When the application has been approved by the State highway engineer and the board of State engineers, an engineer is detailed to execute surveys and prepare plans, specifications, and estimates of cost. The salary of the engineer thus engaged is borne by the State. Other expense incident to the survey is borne by the local body.

State aid may consist of money aid up to 50 per cent of the total cost of improvement, dependent, however, on the funds available at the disposal of the State highway department; convict labor furnished by the State with the approval and under the rules and regulations of the general manager of the State penitentiary, the operating expense of this force being borne by the local body or board benefited; or of machinery furnished by the State and operated at the expense of the local board or body. If the cost of improvement is less than $2,000, and it is decided to execute the work by paid labor, it is discretionary with the State highway engineer as to whether contract shall be let or whether force account shall be used. If the cost is more than $2,000, the State highway engineer, after due publicity given in the vicinity of the proposed improvement, may, with the concurrence of the local boards interested, let the contract to the lowest responsible bidder. The work during progress is under the inspection and supervision of a representative of the State highway engineer. Partial payments covering 80 per cent of the completed work may be authorized by the State highway engineer at monthly intervals. Final payment is made on acceptance of the completed work by the State highway engineer.

Completed roads of this group are maintained under the supervision of the State highway engineer with State and local funds in the same proportions as for construction.

State aid may not exceed $50,000 in any parish in one year if other parishes apply for aid during that period, neither may a parish obtain aid for two consecutive years unless all other parishes applying for aid are supplied.

Parish Roads.—These comprise all other public roads of the State. They are improved and maintained by and at the expense of the parish. The State highway department exercises no jurisdiction over the improvement and maintenance of roads of this group, but may on request of the officials in charge furnish plans and specifications for and advise concerning their improvement and maintenance.

REVENUES.

State.—Revenues for State aid in construction and maintenance of State roads and for support of the State highway department are derived from the imposition of a State-wide tax levied at the rate of one-fourth mill on each $1 of taxable property. This tax produced during the calendar year 1917 about $140,000, of which about $20,000 was expended for the support and maintenance of the State highway department.

Parish.—The funds for road and bridge purposes are derived from various sources, namely:

1. A tax levied at the rate of 1 mill on each $1 of assessed valuation. This rate may be exceeded provided that the total tax for parish purposes does not exceed 10 mills on each $1 of assessed valuation.
2. By transfer of the surplus from the general fund of the parish.
3. By the imposition of an annual license tax on all vehicles except automobiles.
4. By the imposition of a special tax when authorized by a majority vote of the property tax payers elegible to vote in the parish. The tax rate and the purpose for which the proceeds may be used are specified in the proposal submitted to the voters.
5. The net receipts of the State tax on motor vehicles collected and returned by State authority to the parish treasurer.
6. By a per capita tax of $1 per year levied on all male inhabitants between the ages of 18 and 45 and not otherwise legally exempt.
7. By bond issues when authorized by a majority in numbers and valuation of the property-owning voters. Districts may levy special taxes or issue bonds under similar regulations as parishes.

BONDS.

Bonds may be issued in an amount not exceeding 10 per cent of the assessed valuation by parishes or districts when authorized by a majority in numbers and assessed valuation of the property-owning voters. The term of such bonds may not exceed 40 years and the rate of interest may not exceed 5 per cent and the bonds must be sold at par. Bonds must be retired annually beginning at a date not later than 5 years from the date of issue. The amount of bonds outstanding on January 1, 1915, for road and bridge purposes was $1,588,835.26.

MARYLAND' MOTOR TAX IDEA.

Maryland finds it necessary to insist upon taxing motor trucks from other States which use her roads, because, it is argued, reciprocity arrangements with other States were made to cover the comparatively light passenger cars, and with the revolution in motor traffic there must be a revision of charges.

This is pointed out as a concrete illustration of the change which has come over the whole question o motor transportation within the last few years. I regards the change as a permanent one, and say that if there are not freight highways built especiall for this heavy business there will have to be a grea broadening and rebuilding of existing motor routes

SOME STATE HIGHWAY BUILDERS.

(Continued from page 22.)

field in 1916, on account of the unsettled conditio of the country.

Upon returning to Georgia he was employed b the highway department, and in October, 1917, wa elected State highway engineer.

The highway commissioner of Washington, Jame Allen, was born in Kentucky, at Lexington, in 1871 He moved to the State of Washington in 1888 an has been actively engaged in engineering work i the West ever since. In 1908 Mr. Allen becam connected with the State highway department, wa made chief engineer in December, 1913, and i March, 1916, was appointed State highway commis sioner by Gov. Lister. He was reappointed to th office in December, 1917, for the term ending Decem ber 10, 1921.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

Dept. Bul. *53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912-13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
220. Descriptive Catalogue of Road Models of Office of Public Roads.
230. Oil Mixed Portland Cement Concrete
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
370. The Results of physical Tests of Road-Building Rock.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Coat Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETIN.

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

YEARBOOK SEPARATES.

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10. No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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*Department supply exhausted.

*Department supply exhausted.

THE PEACE OF UNCONDITIONAL SURRENDER

Let us not be diverted or deceived by any premature or persuasive pleas there or here for a negotiated peace. There can be but one peace with a robber, an assassin, a rapist, and that is the peace of unconditional surrender.

But if our job is a big one, we are big enough for it. By this time next year we shall have four million more men on the western front, and I have the full confidence that with such a force we will plow through the German defenses to such point as we need to go. I know that our soldiers will do it if we sustain them. In their name I appeal to every American citizen to strip for war as they have stripped--to lay aside every weight of indulgence or comfort that encumbers or delays, to assemble every resource of possession, of body, and of mind, and to deliver the mighty blow of a hundred million freemen against the thrones of autocracy which are already tottering to their fall.

Let me express a bit of sentiment that I hope may be of some comfort to those who dread to read the daily casualty lists. I observed in the Boston Post recently a rather striking statement:

> War always takes the bravest and best of a nation. Somehow it seems that the very ones who have made so much of life, the happy warriors, the shining, lovable, knightly souls are the first to fall. Perhaps it is because death has marked them for his own—that in the Eternal Kingdom there are favored places for the chosen of earth, and because they, whom the world has loved so well, are the sacrifices only a brave people can make.

In a literal and earthly sense that is true, but in a higher and spiritual sense it is not true. You may recall that the first man to fall in the Spanish-American War was Ensign Bagley, of North Carolina. I well remember how, as a southern man, I thrilled at the realization that a State which in my childhood was at war with the Union had then contributed freely of its choicest in the Nation's cause. I was at Raleigh, N. C., a short time ago and I saw Bagley—not in the flesh, but in marble—on the State House Square, and I said Bagley is not dead, for I realized that he lives in the heart of every North Carolina youth. In Texas not long ago I witnessed a striking parade at the beginning of the Red Cross drive. The most commanding figure in it was a handsome young woman accoutered as Joan of Arc riding a white horse, and I said, Joan of Arc is not dead but she lives and lifts the heart of every girl in the world. So I like to feel that Edith Cavell, the martyr nurse, is not dead, but in robes of white moves among the battling Britons whether they stand with their backs to the wall or swarm forward across the fields of Flanders. The French who fell at Verdun are not dead but are leading the hosts of their countrymen in another advance across the Marne. The sons of Italy who were betrayed in Italia Irridenta are not dead, but are back across the Alps inspiring their comrades to heroic defense and fresh offense. Your son who may fall in France will only give to the purifying earth his worn and soiled garments of clay and rise in shining garments to be by your side every day that you live. There is no death. What we call death is only a process of life. The thousands that seem to give their lives in this world war will not have died. They will return and will inspire us to erect a purer and nobler temple of civilization.

CLARENCE OUSLEY,
Assistant Secretary of Agriculture.

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BUREAU OF PUBLIC ROADS

Public Roads

VOL. I, NOS. 6-8 WASHINGTON, D. C. DECEMBER, 1918

ON PHANTOM CANYON HIGHWAY, COLORADO

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1919

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both houses of Congress. Others desiring to obtain PUBLIC ROADS can do so by sending 15 cents for each number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

The Bureau of Public Roads and the Government Printing Office desire to issue PUBLIC ROADS regularly each month, but long delays often are unavoidable, as in the case of this, which, while preserving its regular number, 6, is issued as of December, and necessarily will make Vol. I consist of ten numbers instead of twelve. The delay, however, has afforded the opportunity of incorporating late matter, notably that touching the death of Logan Waller Page.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

BUREAU OF PUBLIC ROADS

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Jules L. Goldberg . Chief Editorial Division

TRIBUTE TO LOGAN WALLER PAGE.

Delivered by A D WILLIAMS at Chicago, Dec. 11, 1918.

WITH sad hearts the Nation bows with us to-day beside the body of one of her noted men, Logan Waller Page, our companion and friend, who by word and deed gave his time, energy and strength, his "all" we might say, as a pioneer of road building in America.

When most of us gathered here scoffed and doubted, Logan Waller Page utilized his daylight hour and burned the midnight oil, studying the problem of our highways. His works have helped to make possible our presence to-day.

His position was not one of large remuneration, but one of vicissitudes and worry. The past years' burdens have borne heavy upon him. His struggles with bureaus and committees, coupled with the anxiety he felt for what might be done here took their toll. Conversations with him just before his death revealed his deep interest in the question near his heart. His efforts were guided by unselfish motives. He, in common with honest men, was sometimes misunderstood, misquoted, and misjudged by those who would further selfish interests.

The pioneer in the field of science is not guided by visions of material gain. It is not the thought of pecuniary returns that impels him to spend his hours, days, weeks, and years seeking hidden truths whose revelation is to find appreciation only in the passage of time. Back of the action, back of the man, there is an unselfish and divine impulse of the soul that compels him to contribute of his life that part which makes other lives brighter and the world better, that part which will help to lift the load from his fellow man. Logan Waller Page has contributed much to smooth the ways of travel, to turn aside the stones over which we stumble, to widen the avenues along which we must work, and has made safer, brighter and lighter the Nation's pathways for the feet of commerce, liberty and happiness. He had his faults as all men have; he would not have been human nor would he have been a man without them. With some of his views many did not agree, but regardless of personal opinion, every man who came into contact with him was compelled to recognize that there was a sincerity and fixedness of purpose backed up by a spirit of fairness.

It is said that when Napoleon, at the close of his career, was asked what he considered the greatest and most beneficial act of his life, after a pause, stated, "The system of roads I have given France will be the most beneficial to her." It took almost a century of time and the recurrence of a war to corroborate that statement; but there is none of us to-day who will not agree that the roads of France saved her and civilization.

The highways of America, though incomplete and inefficient, as they have been in the present crisis, nevertheless contributed to win the war and save democracy, and when we stop to think that few men in America have done as much, have contributed as loyally, as faithfully, as persistently and as conscientiously for the improvement of our highways as Logan Waller Page, we can not but feel that America has lost one of her worthy men; one who strove sincerely to foster within the Nation a desire and an appreciation for a system of transportation that would reach every hamlet and establish firmly and forever civilization in every section.

Those of us who were permitted to live near Mr. Page and came in contact with him learned to love him. Those of us who have fought with and against him, have agreed and disagreed with him, learned to appreciate him because of the honesty of purpose with which he strove. As an earnest friend of better government he worked continually and effectively for efficiency in administration of public affairs. He believed that the road problem could be solved only through scientific research, observation, constant and honest administration. He sought and recommended the employment of trained men, so that the improvements made on our highways would be as permanent as possible; but at the same time he sought to foster the cooperation and friendship of the man who lived by the side of the road. He sought at all times to get the highest efficiency at a minimum cost. He was diligent and faithful to his task.

It was his oft expressed wish that when the end came it would find him in the midst of his work. His wish has been granted. If his silent lips could speak and we were asked what should be done to commemorate him I know that he would say to each and every one of us, "Do your best honestly, faithfully, sincerely and economically to remove from the pathways of the Nation the barriers and burdens that bear it down and make the citizens of many sections slaves of mud and neglect."

Nothing, my friends, that we could say here would add anything to or detract from Logan Waller Page or his life. His story is written, his life speaks, his works live and will live long after we have passed from this hall.

Logan Waller Page

1870—1918

A Tribute to Logan Waller Page

Logan Waller Page, Director of the Federal Bureau of Public Roads, whose sudden death occurred at the Hotel La Salle, Chicago, ten P. M. December Ninth, Nineteen Hundred Eighteen, while attending the annual meeting of the American Association of State Highway Officials, of which he was an active member, was and can be classed the Nation's real pioneer in scientific highway construction. By word, pen, act and deed from his early boyhood to his untimely removal he has contributed unceasingly his entire strength energies and time towards the establishment of better methods and more scientific statutes for all of the states and the nation.

He, more than any other one man, has stood always for scientific road construction, for education and the use of educated and experienced engineers in carrying out road work.

He was inevitably, firmly and unalterably opposed to political appointments and to any interference or influence by outside interested parties.

By the death of Logan Waller Page, this association and the road builders of the whole United States have lost one of its members who cannot be replaced.

A cultured gentleman, scientist, experienced counsellor, faithful and lovable friend; we desire to join with his family and his multitude of friends in mourning his loss

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[illegible] State Highway Engineer

HOW COUNTRY MET MAINTENANCE PROBLEMS OF THE PAST YEAR.

MAINTENANCE of thousands of miles of roads so that the enormous Government and commercial truck traffic of the past 15 months could move has taxed the abilities and called forth every energy and possible plan on the part of the highway officials of the country. To the road destruction which naturally followed the increase of traffic, and a traffic for which the roads were not originally constructed, was added during last winter the difficulties of almost unprecedented snow blockades. In many States officials found themselves without sufficient funds to properly handle the repair and rebuilding work necessary. Nearly all of them had to struggle under the handicap of an insufficient labor supply and all had to meet the increased cost of labor and materials. Only a few States were unaffected by the restrictions on the supply and transportation of materials which had to be brought from a distance.

None escaped the difficulties which followed the great and rapid increase of traffic which so suddenly followed our entrance into the war. From New England to the Pacific coast new demands were made upon the highways and unusual conditions developed everywhere in maintenance and construction.

Highway officials some time ago were requested to write for Public Roads of the maintenance problems which had developed in their respective States and of the way in which they had been solved. The articles received tell interesting stories of the difficulties which had to be overcome in order to keep roads open for traffic, and contain much that will be of great value in planning for future construction and maintenance.

TRAFFIC AND STORM DESTRUCTION.

The States in which the heaviest traffic centered are those north of the Ohio and Potomac Rivers and from the Mississippi to the New England coast. In these States there has been a constant procession of heavily loaded truck trains, and the breaking down of even the best type of roads has been frequent. It is worthy of note, however, that before the end of the summer most of the difficulties arising from this condition had been fairly well met. In Colorado and other States in the West there was not only a largely increased automobile and truck traffic, but roads were destroyed by unusual storms, making both a maintenance and construction problem to be carried on under adverse conditions.

In Pennsylvania, New York, Ohio, Michigan and other States it was necessary all last winter to fight the snow blockades. Officials tell how roads were kept open. For the coming winter plans have been made for keeping the roads clear of snow by the purchase of plows and other equipment, through better local organization and in other ways. In some cases special funds have been provided.

PATROL SYSTEM IS NECESSARY.

In several States high type roads which had originally been constructed without sufficient foundation to meet the new demands had to be rebuilt, and part of this construction work was carried on while the heavy traffic was kept moving. Nearly all the articles show the increased dependence upon local material for repair work and for new construction. Costs of construction advanced to such high figures that appropriations proved too small and work that was done was to solve immediate problems, and that of a more permanent nature left for the future.

Several writers emphasize the importance of the patrol system. There is very general agreement that such a system is absolutely necessary to efficient and economical maintenance.

Wisconsin's System of Road Maintenance Has Given Good Results.

By JOHN A. HAZELWOOD, Chairman Wisconsin Highway Commission.

THE Wisconsin Highway Commission on May 1, 1918, under the State highway act passed by the legislature in 1917, took over the maintenance of a 5,000-mile State trunk highway system. The act referred to not only required the Wisconsin Highway Commission to assume the responsibility of maintenance of the State trunk highway system but liberally provided money for the highway work.

The automobile license fees in Wisconsin were doubled, and from them a fund of over $1,000,000 was created for the purpose of maintaining the system.

GIRLS DRAFTED FOR ROAD WORK IN WISCONSIN.

TYPES OF THE STATE'S HIGHWAYS.

When the State assumed the maintenance of the 5,000-mile system there were approximately 100 miles of concrete surface, 600 miles of stone macadam surface, 1,200 miles of gravel surface, 200 miles of shale, and 3,400 miles of earth road.

The condition of the concrete road at that date would be classed as good. The only maintenance required was taking care of the joints and cracks and some shoulder and ditch work.

The condition of the stone macadam varied to a great extent. Probably 400 miles had been surface treated. Some of it was in good condition, but a large percentage of it was either in a fair or poor condition, and the balance had never been surface treated, and in many instances was in fully as good a condition as some of the surface treated portions that had not been properly maintained.

Of the gravel and shale, probably 50 per cent had been constructed under our State aid law and was in reasonably good condition in so far as shoulders and uniformity of surface was considered, although in many instances it required new material as the surface was becoming worn. The other 50 per cent was ordinary town gravel roads. Material had been dumped in loads very unevenly; the grade in many instances was narrow and very poor drainage had been provided.

Probably 25 per cent of the 3,400 miles of earth road had been previously built with State aid or county funds and was in reasonably good condition to be maintained. The balance was ordinary town roads on which no great amount of work had ever been done, and in many instances little drainage whatever had been provided.

PATROL SYSTEM AND MILE POSTS.

The commission determined at the outset that the only method for the proper maintenance of so large a system of roads, including probably 3,000 miles that had never received any intelligent maintenance, was by a patrol system.

The act creating the State trunk highway system also provided for a systematic marking. The Wisconsin marking system is probably the most thorough and complete system anywhere to be found. Direction signs are used so that it is impossible for travelers to lose their way who tour the State from east to west and from north to south without making inquiries as to which road to travel. The system also includes mile posts, 5,000 of them used on the system, upon which are indicated the number of miles, west from the eastern part of the State on roads running east, and the number of miles north from the southern part of the State on roads running north and south. The marking system at intersections also includes a complete lot of signs giving distance and directions to villages and cities. Danger signs are put upon the system at all sharp curves, railroad crossings, and other dangerous places.

Under our State trunk highway law the counties must maintain the system under the supervision, direction, and advice of the highway commission. The trunk highway system passes through each county seat and all cities of 5,000 or more inhabitants. Therefore, a portion of the system lies within each county of the State and the portion so lying in each county has been divided into patrol sections of from 6 to 10 miles each. Patrol sections vary in length according to traffic conditions, type of road, and location of patrolman employed.

DIVISION OF THE FUNDS.

A sum of money from the automobile fund has been set aside for each section sufficient to provide the salary of patrolman and any assistants on patrol maintenance that he might necessarily require. The balance of the maintenance funds available from the automobile license fees in each county was distributed over sections requiring special work such as heavy blade grader, scarifying stone or gravel surfaces, surface treatment, and surfacing old macadam or gravel roads.

The patrolmen are hired for the season on a monthly basis at an average salary of $130 per month for man and team, the county furnishing the necessary tools. The patrolman gives his whole time to the work during the season for which he is employed. He is required to be on the job from 7 in the morning until 6 at night with one hour off for luncheon. On earth road sections as soon as the surface is dry enough after each rain the patrolman makes one round trip over his section with a light grader. He drives nearly in the center of the road, generally throwing material from the center out. The idea is to immediately fill ruts caused by traffic. After this first trip with a light grader, the road planer is used to smooth up the surface. The Wisconsin Highway Commission does not believe in high crown roads even on heavy clay soil. We obtain good deep ditches where possible, our maintenance cross-section providing for 24-foot width from shoulder to shoulder with a crown not to exceed 8 inches.

HEAVY BLADE GRADER WORK.

Any portion of a section deemed impossible to maintain in its present condition has been ordered graded by a small gang consisting of tractor engine operator, grader operator and about two men and teams with fresnos or slip scrapers. We have completed to date about 300 miles of this heavy blade grader work. Results have been very satisfactory and the highways have been easily maintained. A 40 horsepower tractor and a 10 or 12-feed grader is used for the grading operations and all surplus material in cuts and on high places is slipped ahead by the teams to some low point. By this method the grade is widened out to 24 feet except only in cuts or on high narrow fills and in the latter case, a guard fence is placed on the fill for protection to travelers.

The gravel roads have been maintained by the adding of new material where needed on those built by state or county aid. On those portions that have been built by the towns in previous years it has been found necessary in the majority of cases to scarify the surface to the full depth of material placed, thereby making it possible to even up the surface with a road grader so that when rolled down again the wavy appearance will be entirely removed. Scarifying in this way also permits the removal of any coarse stone or gravel that may have come to the surface. We have scarified approximately 200 miles of roads during the past season at an average cost of $75 per mile. The improvement in the highways for travel indicates that it has been well worth the money expended. In some instances new material has been added to the scarified surface and has placed the surface in a condition to be maintained cheaply by the use of a light grader or a road planer.

UPKEEP OF OLD MACADAM ROADS.

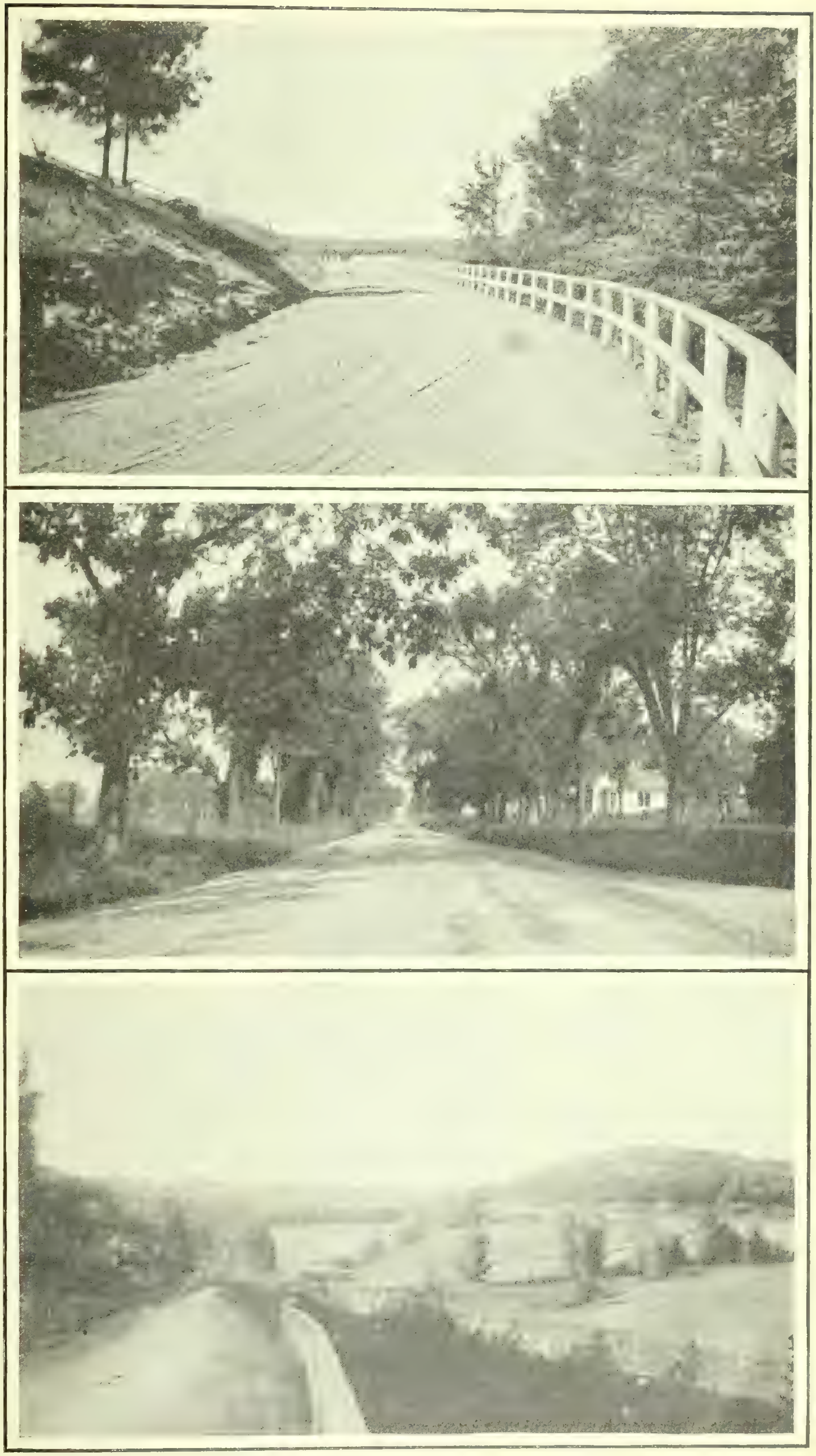
The stone macadam roads receiving the heaviest traffic, which is generally near some good market town, have been surface treated as usual whenever possible to do so, but quite a large portion of the stone macadam roads that had been previously surface treated we found it either impossible or impracticable to surface treat this year. The cost of bituminous material combined with unsatisfactory delivery of it has caused us to hesitate to surface treat some of the roads, especially where they were not in proper condition to receive the treatment.

Other methods have been resorted to, one which has been found very satisfactory. That is, by scarifying the old surface to the deepest hole on the surface, shaping up the road to a proper crown which should be reasonably flat, and after having compacted the surface, covering the same with 1½ inches to 2 inches of fine gravel or good sharp sand. In many instances we have placed the covering on the old macadam surface without scarifying and have obtained very good results by this method. When the old surface has been covered with gravel or sand the patrolman can keep it in place by the use of a light grader or a planer after each rain and we find this surface fully as satisfactory to drive on as the surface treated macadams. Concrete roads have been taken care of by the ordinary methods of filling the cracks and joints with bituminous material, covering it with a light coat of good sharp sand, taking care of the drainage and keeping the shoulder material in place.

SATISFACTORY CONDITIONS.

The condition of the system at the present time, October 24, 1918, is indeed very satisfactory. The earth road sections, due to the persistent efforts of the patrolmen and the gang maintenance crews are now in splendid condition. The speed at which a car may operate over these roads depends largely upon the speed the car can make, as the surface in nearly all cases is very smooth. On the majority of the gravel roads all waves and holes have disappeared and the surface is in much better condition than we expected to get it in one season. A few of our macadam roads where traffic is extremely heavy are probably in no better condition than they were at the beginning of the season, but in the majority of cases we believe they show a decided improvement.

For convenience in handling our road problems the commission has divided the State into eight districts with a division engineer in charge of each district who looks after



WISCONSIN TYPES OF ROAD. TOP—TYPICAL EARTH CONSTRUCTION. CENTER—GRAVEL. BOTTOM—TYPICAL MACADAM.

the construction and maintenance: also in each division there is a maintenance engineer and a force of three or four men who make surveys and plans.

At a recent conference of the division engineers each was asked to state his views as to the increased improvement of the roads in his division due to patrol maintenance. The average estimate of increased improvement as determined by them was approximately 75 per cent. They were also requested to give their estimate of the increase in miles per hour that a traveler could make over the system to-day as compared to a year ago. Each division engineer took some specific road over which he had been accustomed to travel other years and knew the time required to travel between two points, comparing it to the time required between the same points now. The average estimated increase was 8 miles per hour, which is believed to be a very conservative estimate.

LABOR PROBLEMS NOT SERIOUS.

The labor problem, in so far as maintenance work is concerned, is not serious. We have 550 patrolmen and the majority of them are men well up in years, in many cases men who have retired from the farms. A very small portion of our patrolmen have come within the draft age. State aid construction has been cut down to the very minimum in Wisconsin this year, and this has made available quite a large number of men and teams formerly employed on that work, and they have made excellent men for maintenance service.

Many of our counties are using motor trucks for hauling maintenance materials for surfaced roads and in many instances are using machinery for loading trucks, thereby reducing the labor cost. We have several small portable gravel crushing plants where material is delivered to the crusher by team and scraper and is properly crushed and screened, and in many cases is hauled a distance of from 5 to 10 miles, making a very good and reasonably cheap maintenance material. The cost of the work compared with normal years has probably increased to the extent of 40 per cent. However, the increase would be greater if it were not for the fact that in nearly every county motor trucks are being used to deliver maintenance material, reducing the cost for that part of the work from the former cost by team delivery.

TRAFFIC CONDITIONS IN STATE.

The character and volume of the traffic which has a tendency to destroy the road surface is changing and increasing rapidly.

We have some 10 or 12 motor-truck manufacturing plants in Wisconsin that use the roads tributary to their plants for the purpose of trying out new trucks to such an extent that it has a decided bearing on the maintenance work near those plants. In nearly all instances there is some bad hill near the plant or some stretch of surfaced road that is used for demonstration purposes. Frequently a train of trucks making its way east for delivery use our highways. We also find in some of our earth road sections that timber for war industries has been purchased and must be hauled immediately, and it is not uncommon to see a train of teams with exceptionally heavy loads of lumber making its way across our highways to railroad points. These heavy loads on narrow tired wagons are extremely destructive to the earth roads. Ordinarily this kind of hauling is done in winter months on sleighs. Some is hauled, however, during the summer and fall over our trunk highways. In the lead district, in the southwestern part of the State, we find many of the mining companies have installed heavy motor trucks for hauling the ore to shipping points. Many of them carry 5 tons or more, and this traffic is extremely destructive especially to earth roads.

MILK AND MERCHANDISE TRUCKS.

Wisconsin has 60 large milk condenseries, furnishing canned and condensed milk, with daily receipts at each of from 150,000 to 200,000 pounds of milk. The majority of the milk is delivered to the condenseries by motor trucks. This is done 365 days a year and one can readily see the effects of this traffic on the highways. These condenseries usually haul their milk from a radius of from 10 to 20 miles. Sections over which this traffic goes need intensive maintenance in order to keep the roads in good condition. Many hundreds of creameries throughout the State are also receiving the milk by motor trucks. All this traffic has a tremendous effect upon the surface of the roads traveled.

The number of motor trucks is increasing rapidly in the rural districts. We have in Wisconsin hundreds of small inland towns which buy produce and furnish groceries and merchandise to quite a tributary territory. In nearly all cases the goods are delivered from the railroad to the inland town by motor truck. Many of these small towns have as high as 8 or 10 motor trucks which travel an 8 or 10 mile stretch of road daily with their loads. We notice in some localities that the farmers are hiring these same trucks to deliver their hogs and cattle to the market. This traffic naturally affects the maintenance of the highways to a marked degree.

We are all well satisfied with the patrol system of maintenance on our 5,000-mile system after this season's trial. We are so well pleased with results that the Wisconsin Highway Commission hopes to induce the county board of each county to adopt a secondary or county truck system and install patrol maintenance on this secondary system. In fact,

some of the counties have already done so. If this were accomplished it would place practically all of the main roads of the State in first-class condition to travel throughout most of the year.

KEEPING UP CLAY AND SAND ROADS.

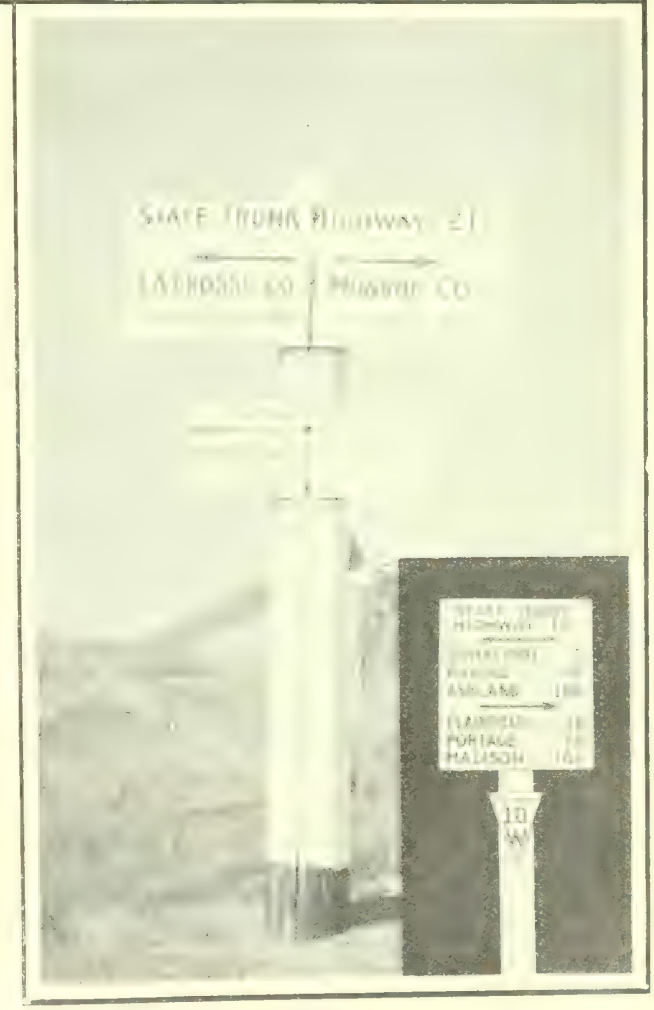
We find that a heavy clay road can be made a good road to travel almost every day in the year by adding 2 or 3 inches of sandy gravel or even sand if the gravel can not be obtained. We would not advocate this, however, unless the road so treated is maintained by the patrol system. Two or three inches of gravel will not hold up the traffic immediately but if gone over after each rain with a light grader or planer, in a short time the surface of the road will become so thoroughly solidified that it will maintain the traffic in a reasonable way. Any holes appearing that can not be filled with a light grader will be filled by the patrolman with new material. By this method the clay roads can be maintained in a very satisfactory manner.

Our sandy sections are being taken care of by pushing out the old worn-out sand from the center of the road and moving in with a road grader new unused top soil from along the roadside, making a fairly satisfactory wearing surface for light traffic. In some instances, clay, shale, or gravel must be placed on the surface before the sand road can be considered satisfactory.

Wisconsin now realizes the importance of proper maintenance of public highways and it is certain that no reaction can set in so as to make the State take any backward step in the movement for highway maintenance.

CONCLUSION.

After the Civil War closed, railroad construction and maintenance developed by leaps and bounds. Distribution facilities were lacking and our people gave large thought and attention to developing our steel highway system. With the winning of the war for democracy, the people of this country will again give serious attention to methods of distribution. In early times tribes and clans were satisfied with living unto themselves. Their food and clothes were produced in their homes. How different are the economic and social conditions of today.



TOP—STANDARD HIGHWAY MARKER ON WISCONSIN ROAD.
BOTTOM—COUNTY LINE AND PATROL SECTION SIGNS.

Little of the necessary food and clothing of mankind are made in the community in which we live. Production, transportation, and distribution are the

TRAFFIC ON WISCONSIN ROADS—HAULING MILK IN MILWAUKEE COUNTY. TRUCK WITH TRAILER HAULS 128 CANS DAILY, OTHER TRUCKS 75 TO 100 CANS.

economic problems that must be understood and more satisfactorily solved by laymen as well as by legislators. Wonderful have been the improvements in the last century along all lines of engineering. The man of the hour is the engineer. The man of the future will be the engineer. In no one line of activity has there been need of advancement in modern times as in the needs for transportation. Good roads well maintained are essential to the advancement of our people commercially, educationally, and socially. Good roads mean education and liberty while poor roads mean illiteracy and bondage. The roads have been fairly well laid out all over this State and Nation, but the one thing lacking up to the present time has been proper maintenance. Maintenance of wagon roads is the problem needing large attention. Wisconsin has worked out a program that has already given excellent results and promises much for the future.

HIGHWAYS THE BAROMETER OF PROGRESS.

There is exhibited throughout Wisconsin a more progressive good road spirit than has ever been known before. It is recognized everywhere that a community's prosperity and happiness can be estimated by studying highway maintenance. It is said that a community's cleanliness can be determined by the amount of soap used. It is also true that a community's progressiveness can be determined by the condition of its highways. Wisconsin has blazed the way with a new method of road signs or road markings, and established a practical up-to-date policy of road maintenance, worthy of favorable consideration everywhere.

Connecticut Paid More for Its Labor and Saved by Using Motor Vehicles.

By C. J. BENNETT, State Highway Commissioner.

THIS State has a mileage of roads aggregating approximately 1,500, including all types of construction, from city pavements to the ordinary graded earth road. In general the condition of these highways in the spring was as usual, namely, the hard pavements were in splendid condition; some of the waterbound macadam roads were broken up badly and the earth and gravel roads were muddy and broken through as usual. There was some increase in the difficulty experienced due to the increase in heavy truck traffic through the past winter and spring, from which resulted the greatest amount of damage, but in general, it does not appear that there will be any marked increase in this class of traffic over that of last winter and spring.

In general our roads are in good condition after the summer maintenance. We find that they have not deteriorated any more than would be consistent with continued use.

The labor problem was solved by increasing the price paid to laborers, competing in many instances with industries employed on war work where the cost of labor was a secondary consideration. As an indication of the difficulty met in this matter, please note the following comparison between the cost of trunk line repairs of approximately 1,000 miles of road, during 1916–17 and the cost of the corresponding year 1917–18:

Cost, 1916–17	$559,341.74
Cost, 1917–18	679,453.46

These figures are almost a direct comparison showing the increased cost of labor. Material is not included.

Our experience with materials during the summer of 1918 was extremely gratifying. As a matter of fact, we had very little delay on account of the shortage of materials.

Realizing that the use of time and labor-saving devices was imperative, the department purchased an increased number of motor vehicles for the transportation of men and materials, and also increased its facilities for distributing bituminous material by truck, through the purchase of four large tank trucks. In addition, mechanical loaders and spreaders for the covering material were employed.

Following the custom inaugurated a year ago, this department has made careful plans for the removal of snow and the proper maintenance of traffic during the coming winter.

Machinery and the Patrol System Solved Utah's Maintenance Problem.

By IRA B. BROWNING, State Road Engineer.

THE public roads in Utah have withstood during the current year an abnormal traffic under unusually severe working conditions. The protracted storms of early spring developed the the instability of those sections that lack proper foundations and adequate drainage. The protracted drought of the late spring and early summer reduced the strength and resistance of the clay-macadam and sand-clay surfaces, and the increased tonnage resulting from the campaigns for greater production, the additional local highway traffic to relieve railroad congestion, and the enormous loads commonly transported by heavy trucks, have added unusual burdens to the highway systems. Even the hard surfaced roads that have heretofore resisted the traffic satisfactorily have shown pronounced wear and disintegration under the added burdens.

The shortage of available labor has increased the difficulty of making repairs when needed, and the increased costs and labor charges have added greatly to the expense of maintenance.

MODERN EQUIPMENT INDISPENSABLE.

In some cases the imperative need of maintaining the roads in more serviceable condition, under an ever increasing traffic, heavily loaded vehicles, made necessary the relocation of sections of the roads, abandoning the insecure foundations and unsuitable road materials in favor of better locations and more durable road materials. For this work, the steam shovel and other modern road building equipment have proved practically indispensable.

Not only does the use of such equipment result in an immense saving of cost, but it makes possible road construction where teams and men can not be secured. Where costs have been kept on such work in Utah, the range has been from 10 cents to 25 cents per cubic yard of material, generally a mixture of earth, rock waste, and bowlders, in about equal proportions, which would cost from 30 cents to 75 cents per cubic yard by team and man labor, at current wages.

The maintaining of roads has also necessitated the grading and crowning of certain sections. Here again the motor-drawn equipment has demonstrated its value. A typical case was the grading of a road in Utah County, using a heavy grader drawn by a tractor. The total cost was less than $30 per mile, where with horse-drawn plows, scrapers, and graders, the expense would have been at least $150 per mile for the same road.

The use of the road scarifier drawn by either a truck or a tractor, for reducing the irregularities on a gravel or macadam road, and providing a bond for new surfacing material, affords another illustration. The steady pull on the drawbar of a tractor or large truck, together with the uniform speed and the perfect control, render the operation of scarifying roads with power-drawn equipment twice as effective as when horse-drawn implements are used, and much less expensive.

The use of portable compressors and jack-hammer drills has done much toward reducing the time and labor for cutting out defective areas and patching and maintaining hard surfaced roads; also for the removal of intrusive points of ledge rock and the bowlders encountered during excavation.

PATROL SYSTEM MOST EFFECTIVE.

The maintenance of earth and shale or gravel surfaced roads is becoming more of a problem as the traffic and intensity of loading increases. The labor of repairing and maintaining these highways is therefore sure to increase. It has been demonstrated in Utah that the greatest saving and improvement is effected by establishing a patrol system for the main roads. If a foreman residing along the road has a 10-mile section, extending each side of his home, and he is authorized and encouraged to plan ahead for the requirements of his road section, he will have piles of material suitable for repairing ruts and maintaining the road surface in good condition, at convenient points along the road. He will so plan his work that the grading, crowning, dragging, and draining of the roads will be attended to at the proper time, even though this may be outside of the ordinary working hours. Allowing a road section foreman the initiative and placing upon him the responsibility of maintaining his road in commendable condition for traffic, has proved, where the foreman had ambition and capacity, the most economical and effective system yet devised and tested in this State.

The present plans of the State Road Commission include a power unit, such as a tractor or heavy truck, for each county; also the extension of the road patrol system to cover all of the principal State roads.

My conclusions from the year's work are:

1. Maintenance of earth roads under the most severe weather and traffic conditions is most easily accomplished where the native material within the roadway limits and to a considerable depth is a durable and suitable material.
2. Under extreme conditions an inadequate depth of surfacing material on an insecure foundation is practically worthless, as the breaking down of the road surface in spots may render the road nearly impassable. It is far better to provide adequate thickness of suitable surfacing material.
3. The road patrol system for hard surfaced roads, macadam, and earth roads, has proved to be the most effective method of maintaining highways under heavy traffic.
4. The solution of the labor problem in road building requires the use of modern machinery and equipment handled by competent workmen.
5. Just as increased burdens must now be borne by each community with a large percentage of the most active members in war industries or military service, so each highway department must now accomplish more at road construction and maintenance, under heavier traffic burdens and witn a more pronounced shortage of materials and labor than ever before. The absolute requirement is therefore an efficient organization for road building and maintenance, and modern types of roads and equipment.

Keeping up Roads in the District of Columbia for War Traffic

By COL. J. J. LOVING, Assistant to Engineer Commissioner.

THE wear upon the surfaces of nearly all of the roads and streets within the District of Columbia during the winter of 1917–18 and since has been excessive, due to the various war activities in the city of Washington and adjacent territory, which included the construction of many new office buildings, two army cantonments, one munition factory, and one large base hospital, within the District, and two very large cantonments within a short distance of the city. A great shortage of labor and, to some extent, embargoes on shipments of materials have interfered seriously with the prompt repair of the roads and streets. Due to these circumstances it has not been possible to keep the surfaces in first-class condition, but by persistent and continuous efforts they have been maintained in a passable though rough state and in the fall were vastly better than in the spring.

RESURFACING MACADAM NECESSARY.

The greatest difficulty was found in maintaining the macadam roads having oil and tar surfaces; and the Bladensburg Road, which is the main line to Baltimore and Camp Meade, has been almost completely resurfaced twice during this season. The numerous openings and cuts for new construction also greatly increased the amount of work.

Many laborers deserted us for better pay under contractors engaged on the cost plus percentage basis, and their places could not be filled, although wages were advanced during the year about 80 per cent. To offset the loss of labor, machinery was used to a larger extent than ever before, and in grading, however light, steam shovels were employed.

Materials were supplied in limited quantities for repairs only, through the valuable assistance of the

United States Highway Council and the Railroad Administration.

THE COST OF WORK IS DOUBLED.

The cost of work done by contract has been doubled during the year. When done by hired labor the advance in cost was about 80 per cent more than a year ago.

The increase in destructive traffic was mainly caused by the greatly increased use of heavy automobile trucks for hauling construction materials and for army transportation. The use of passenger automobiles was also very largely increased, and it is probable that the traffic endured by the roads as a whole was at least doubled, and in some cases was quadrupled.

The use of bituminous patching material which could be mixed and applied at ordinary temperature to the surface-treated roads has been the principal method employed in maintenance of the macadam roads. The work done ranges from patching to entire reconstruction at the worst places.

It is proposed to continue the maintenance with the entire force that can be secured for the purpose as long as the weather and the state of the roads will permit; and it is hoped by this means to keep the roads and streets in passable condition, though it is not expected that it will be ideal during the continuance of the state of affairs now existing.

Maine's Portable Maintenance Crew Big Factor in State's Upkeep Work

By PAUL D. SARGENT, Chief Engineer.

AT the opening of the spring season this year the main highways were in about their usual condition. As there is substantially no war activity in this State, outside of shipbuilding at Portland and Bath, no extraordinary traffic was brought upon the highways to injure them during the winter and more particularly during the period when frost is leaving the ground and the roads are settling.

The principal types of surface employed on our State highway system are Portland cement concrete, bituminous macadam and gravel, about 80 per cent of the surface being of the latter type. We have two short sections of water-bound macadam surface treated. All of these roads came out of the winter in as good condition as ordinarily they do. About 100 miles of the gravel-surfaced State highway which receives the heaviest traffic has been surface treated with tar during the last four years, and these sections came out in very good shape.

BITUMINOUS MATERIAL SECURED.

Anticipating that there might be some difficulty in securing materials for surface treatment, this commission placed orders as early as January and February, 1918, for their requirements for the year. About two-thirds of our normal supply of bituminous material for surface treatment was delivered in barrels and arrangements were made with the railroad companies to have this unloaded at some point in their yards where it would cause no interference with ordinary yard work and where the material could be loaded into wagons or motor trucks. Ordinarily this material would all have been taken in tank cars. While the cost was about 20 per cent more for the material in barrels than it would have been in tank cars, when the season opened we had the material. The remainder of the material needed was received in tanks, although the order had originally been placed for barrel delivery.

HOW LABOR PROBLEM WAS MET.

Considerable difficulty was experienced in securing labor for maintenance work. During the last two years we have maintained a sort of portable maintenance crew, that is to say, we have had about a dozen men whom we have transported from place to place on the State highway system, and with this crew surface treatment work and resurfacing work has been done. In the past we have held the nucleus of the crew together and boarded them around at different places, depending on filling out the crew with local labor at different points. It was absolutely impossible to do this this year, so we organized a portable camp consisting of two large living tents, a cook tent, a dining tent, and a supply tent. By this means we were able to keep the men right on the work and held a crew of about a dozen men together through the whole season. There were a few changes in the crew, however. We paid this crew $2.50 and $2.75 per day and board and gave them straight time. This crew was supplied with six motor trucks and we had very great difficulty in holding motor truck drivers. Probably we have had not less than 25 to 30 drivers in this outfit this year, those whom we have lost being practically all drafted.

THE INCREASE OF HIGHWAY TRAFFIC.

A traffic census taken at 19 stations at various points on the State highway system during the first week of September in 1918 showed a gross number of vehicles of all kinds of 59,087. At the same stations in 1917 the gross number of vehicles moving during the same week was 56,264. The maximum number of vehicles in one 12-hour period in 1918 was 3,585, and the average number of vehicles at this station for the seven-day period was 1,585, and at the same station in 1917 the maximum number of vehicles was 1,931 and the average for the seven-day period was 1,373. At another station the maximum for 1918 for the 12-hour period was 1,704 with an average of 1,140 for the seven-day period, and in 1917 the maximum was 1,649 and the average was 1,095. These increases in traffic represent approximately the increased number of automobiles registered in the State, but it is fair to note in this connection that tourist traffic during the months of June, July, and August was much lighter this year than it has been in ordinary years. The total registration for automobiles for the year up to October 6 was 40,069 against 37,336 for the corresponding period in 1917, and the total registration for trucks during the year up to October 6 was 4,101 against 3,271 for the corresponding period of 1917.

Pennsylvania Spends $4,500,000 in Keeping Roads Up to Standard

By. J. DENNY O'NEIL, State Highway Commissioner.

PENNSYLVANIA roads have had to bear their full burden of the war, but like Pennsylvania in all war emergencies, it has been equal to the task. Pennsylvania roads have have had to bear the burden of more Army trucks and more trucks loaded with munitions and supplies than any other State in the Union. We have approximately 1,000 miles of roads which can be termed war roads, or roads that are being used by Army trucks or by Government trucks for the transportation of munitions and supplies. Many of these roads were constructed several years ago and at that time no one even dreamed that they would be called upon to carry loads of 10 and 15 tons, therefore the question of maintenance has not only been a big problem but a very expensive one. Some idea of the cost of this work can be conceived from the fact that we spent over $600,000 for maintenance and repairs on the Lincoln Highway alone, while the total amount spent for maintenance in the State exceeded $4,500,000.

STONE CRUSHERS AT STRATEGIC POINTS.

During 1917 we had trouble getting material for maintenance on account of the congestion of the railroads and on this account we decided late in the fall to open up quarries and place stone crushers at stragetic points throughout the State where we could deliver stone upon our important roads by trucks; 75 quarries were opened and this plan has proven very successful as we not only produced the stone at a saving in price but we had the stone ready when we needed it. This year we were very fortunate in securing bituminous material for road treatment and I am glad to say that our roads now are in splendid shape and ready for the great strain which they will have to endure during the coming winter.

Throughout the coal regions thousands of small mines have been opened and this coal is delivered to shipping points and industrial centers in wagons and in trucks. Some idea of the magnitude of this business can be formed from the fact that Altoona was supplied with coal in this manner and many of the large industrial plants in the Pittsburgh district are supplied entirely by wagons and trucks. Roads used by coal trucks have been very hard to maintain, but with very few exceptions we have been able to keep them in good shape.

We have been very successful in securing labor for road work this year by establishing commissaries and by assembling men in the rural communities at various points and transporting them, to where the work is in progress, in State trucks.

We have found that the average cost of maintenance including labor and material has been about double that of normal years.

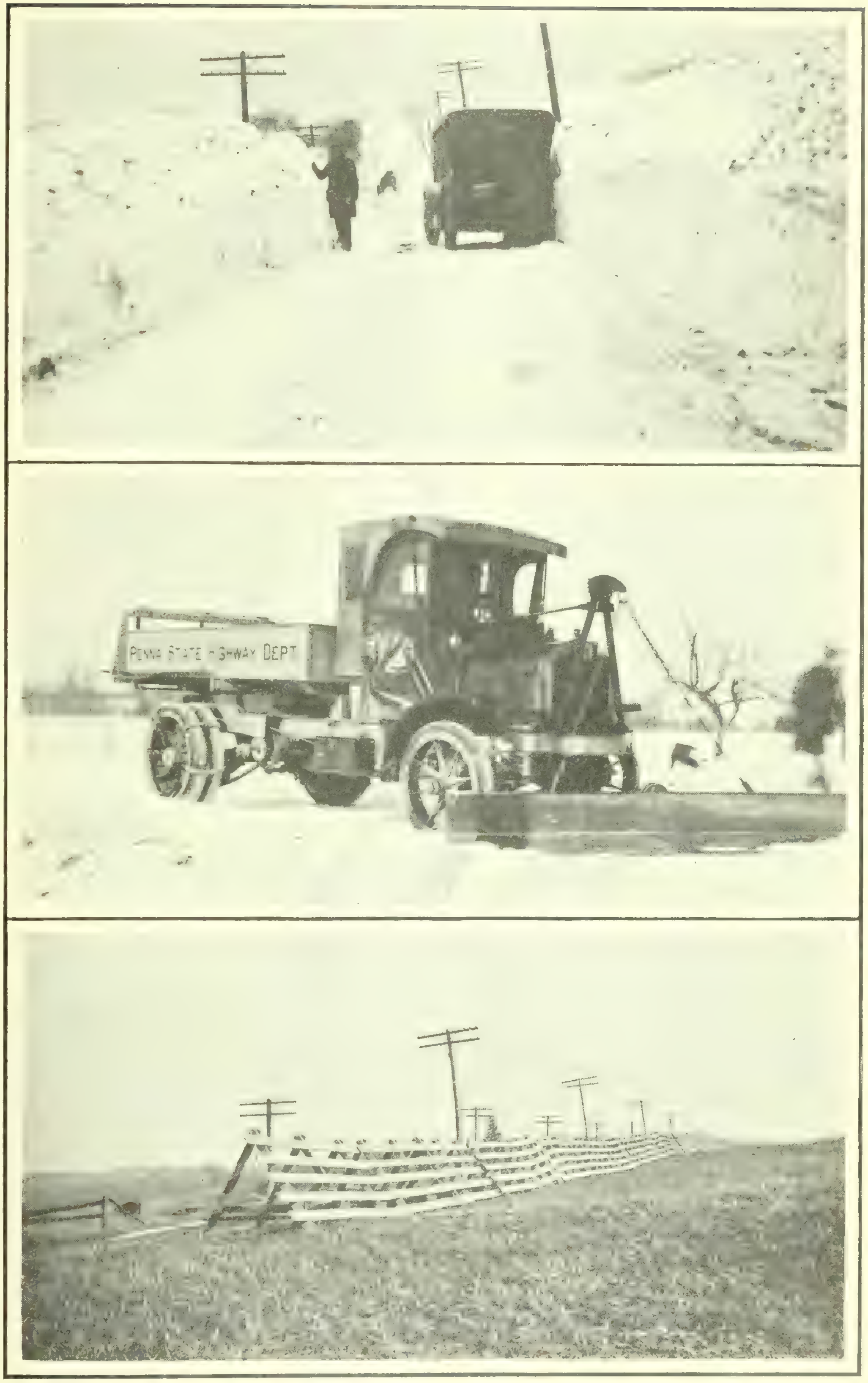
DISTRIBUTION OF TRAFFIC BY TRUCKS.

Truck transportation has been growing by leaps and bounds, practically all of the wholesale houses and many of the manufacturers in the large industrial centers throughout the State are now distributing their products within a radius of 20 to 30 miles by trucks. Several express and freight truck routes are now established and run daily in the eastern and western part of the State. During the past year thousands of families have moved from various localities to industrial centers where war work is in progress and with very few exceptions all of these movings have been transported by trucks, and this has made an additional burden for our roads to carry.

One of the most interesting war roads is the 12 miles in Beaver County from the Ohio State line to Beaver Falls. When the Government selected this route as the one that they would move their army trucks over it was one of the worst earth roads in the State, several miles of it running through a regular swamp. This spring we undertook to build a slag road and in some places we had to put as much as two feet of slag on before we could get a good foundation. This road was constructed with our State forces. We have placed a water-bound top on it. This completes a hard surface road throughout the entire State of Pennsylvania from the Ohio State line to the New Jersey State line, a distance of 360 miles.

SOLUTION OF THE SNOW PROBLEM.

One of the big problems brought about by the war is that of keeping our main highways, particularly through the mountain sections, open for the transportation of army trucks and trucks loaded with supplies, during the winter. We succeeded in doing this last winter, notwithstanding the fact that it was one of the coldest and most severe winters ever experienced in this State. Last fall we equipped many of our 5 ton trucks with snow



FIGHTING SNOW ON PENNSYLVANIA ROADS. TOP—DRIFTS CLEARED FROM BEAVER COUNTY ROAD USED BY GOVERNMENT TRUCKS. CENTER—SNOW-PLOW TRUCK ON ADAMS COUNTY HIGHWAY. BOTTOM—SNOW FENCE ON LINCOLN HIGHWAY IN BEAVER COUNTY.

plows and organized snow gangs and placed them in charge of competent foremen, with the understanding that they would come out at the approach of a snow storm and keep the road in their particular section open for traffic. Many of these men suffered untold hardships, several times they worked 48 hours without sleep and often with the thermometer below zero, but they were successful, and with the exceptions of one or two days when the snow drifted very badly, Government trucks were able to pass from the Ohio line to the seaboard loaded with munitions and supplies which are now being used by our soldiers in France in their great fight for democracy. During the entire winter we had sentinels placed along the road to warn trucks of dangerous snow drifts and slides, and these men made daily reports to the weather bureau in Pittsburgh and many of the daily papers throughout the State printed daily bulletins as to the temperature and the condition along roads used by the Government. This year we are preparing on a larger scale to battle with the snow. Additional trucks have been equipped with snow plows, road machines will be stationed along the roads and arrangements made with farmers to furnish horses to pull them; snow fences will be erected where we had the greatest trouble from snow drifts last winter, and we are satisfied that we will be able to maintain traffic this winter not only upon the war roads but upon all other important roads throughout the State.

CONTRACTS LET FOR 71 NEW ROADS.

We have awarded contracts for 71 roads, practically all of which connect county seats or industrial centers and are roads which will form part of a definite system. In almost every instance we have been successful in getting the local authorities to pay half the cost. The roads are located in 33 counties; the total mileage of new construction is 150.52; the total amount of money involved is $5,407,678.87. The contributions made by the local authorities plus $567,360 Federal-aid money totals $2,356,929.01, this leaves a balance of $3,050,749.76 to be paid for by the State. The types of construction are as follows:

Reinforced and plain concrete	43
Brick on concrete base	18
Water-bound macadam	2
Bituminous macadam	1
Bituminous concrete	2
Asphaltic block	1
Grading and drainage only	4
Total	71

Motor truck transportation is just in its infancy; manufacturers, farmers and men in every line of business realize the importance of well constructed hard top roads, and in my opinion after we lick the Kaiser Pennsylvania is going to enter upon an era of road building which will not stop until the entire State is linked up with a system of improved roads.

Dragging System Main Feature in Caring for Kansas Earth Roads.

By GOV. ARTHUR CAPPER, Chairman Ex-Officio, Kansas State Highway Commission.

ROAD construction in Kansas under the supervision of the State began about one year ago. After some months of investigation and holding hearings with the people throughout the State, the highway commission established a system of about 6,500 miles of State roads.

The constitution of Kansas forbids State aid in any public improvement and therefore the commission had no financial inducement to offer to the people except Federal aid. They adopted the policy of offering 15 per cent of the total cost of the road, having in view that the people would build the roads if they felt the necessity and saw the benefits derived.

War conditions brought about a stringency of labor and enormous increase in the cost of materials to such a rapid extent that construction was almost out of the question. However, the commission continued to receive applications and has passed upon a number of projects.

THE DISTRICT BENEFIT PLAN.

The Kansas law permits the construction of permanent roads by a benefit district plan. After the Federal aid has been deducted, the road may be constructed upon petitions from the people to the board of county commissioners. If they declare it a public utility, the county pays one-half the cost of construction, the townships through which it passes pays 25 per cent, and the benefit district pays 25 per cent. The petitions specify the bounds of the benefit district, but as a rule it extends about 1½ miles on each side of the road.

Up to the present time petitions have been granted for about 550 miles of hard-surfaced road at an estimated cost of $7,500,000. It is hoped to begin construction on a number of these projects as soon as the war situation brings the commercial life to a more normal condition.

Kansas farm products this year are valued at approximately $550,000,000 and the transportation of these products to market has been handled almost exclusively over earth roads. In many cases the truck took the place of teams. While the man power is short in the road-dragging feature, machinery has been substituted in a great many cases and a larger number of miles could be dragged than when using horses.

MOTOR FEES TO DRAGGING FUND.

The State of Kansas this year will raise approximately $875,000 from the license fees on automobiles. By State law this entire fund is to be used for road dragging, and yet in a number of instances it has been impossible to secure the man power to expend this fund in an expeditious manner.

Kansas has a law whereby the county prisoners and prisoners in the State penitentiary may be utilized for road construction, but, as is well known, a large majority of the counties do not have any prisoners in their county jails and those in the State penitentiary are used in the binding twine plant and coal mines owned by the State.

The road-drag fund can be used by the counties in removing snow in the winter time as well as smoothing down the ruts after a rain. This method was very successfully carried out in several counties last winter.

PATROL SYSTEM IS NECESSARY.

The experience of the past year gives added evidence to the fact that road maintenance, whether on an earth road or a hard surfaced road, must be handled through patrolmen, taking a definite territory, instead of depending on the farmers who are so busily engaged in other affairs. The counties of the State are investing very generally in trucks and stone crushers. Many counties find that they have fine deposits of gravel that have been unnoticed through the years and these counties are making large plans to have an extensively constructed system of gravel roads covering the entire county.

While this State, next to Texas, has the largest road mileage of any State in the Union, and has been rather negligent in planning a systematic, concerted method of road construction, the experience of the past year shows that she now has the matter well in hand and will rapidly construct highways which will aid materially in the transportation of the extensive crops for which this State is noted.

Use of Local Materials and Patrol System Help Much in Michigan.

By L. H. NEILSEN, State Maintenance Engineer.

MOST of our roads have a gravel or water-bound macadam surface. There are no roads maintained directly by the State.

Due partly to favorable weather conditions the gravel-surfaced roads came through the spring in very good condition. Labor shortage and difficulty in securing rail shipments made the task of maintaining the roads an unusually hard one. A long dry period caused unusual raveling of the surface which did not improve conditions. These difficulties have to a large extent been met by the use of local materials and the development of the patrol system. Wherever adopted and faithfully worked out marked economy of labor and material have resulted.

FLOATING WORTH THE COST.

It has been demonstrated that floating with the ordinary steel or wooden floats even in dry weather is well worth the cost. Indeed on some high traffic roads daily floating regardless of weather conditions has been found necessary to preserve the surface even in fair condition.

In cases where this is necessary constant application of new material has been found most satisfactory. This gravel should contain no material passing a one-half or three-fourths mesh and should contain 30 per cent to 40 per cent of material passing one-eighth mesh. It should be placed in thicknesses not to exceed 1 inch in thickness and should be replaced as often as is necessary to insure that some loose gravel is always present. There must be some material loose on the surface if dry floating is to be of any benefit.

Mechanical power for floating has not been an entire success because of the tendency of the operators to go too fast.

Local materials are being utilized more than ever.

SURFACE TREATMENT GIVEN.

Car shortage made it extremely difficult to secure crushed stone or chips for water-bound macadam maintenance. Two methods were used on such work. On a large number of miles of water-bound limestone macadam surface treatments have been given. Cold bituminous material is applied at the rate of one-half to three-fourths gallon per square yard. This is put on in two coats and the last treatment is covered with sufficient chips or pea gravel to take up any excess material. Slag chips have been used very successfully for this purpose.

The same method has been used to some extent on water-bound cobblestone macadam and on gravel roads.

Surface treatment of those types of roads has not been so successful, due mostly to the fact that they can not be swept entirely free from loose material without endangering the bond of the road itself. In some cases fair success has been obtained, especially where gravel roads have been built of gravel substatially by macadam construction methods.

Very satisfactory results have been secured by the use of a low test gravel containing a very small amount of clay or loose filler. This material is put on in sufficient amounts to fill holes and ruts and leave enough material to float. The road is then maintained by the patrol system using the same methods that are being used on gravel-surfaced roads.

NEW TRAFFIC PROBLEMS.

Traffic increases are due to increasing use of motor trucks for inter-city transportation and for transportation of farm products from farm to market.

The large increase was observed in driveaway deliveries of passenger automobiles and trucks. Due to the decrease in the output of pleasure cars driveaways of that class of vehicles is decreasing very rapidly. Motor trucks both war and commercial are being delivered under their power in ever increasing numbers. War trucks are being driven away loaded.

The State highways transport committee is engaged in organizing motor express routes. These will place a still heavier burden on our highways which can only be met by more intensive maintenance. This must be accomplished by more general adoption of the patrol system and by careful development of the systems already installed.

Machinery and Local Materials Factors in Colorado's Big Problem.

By T. J. EHRHART, Colorado State Highway Commissioner.

OTHER States have seen their highways torn to pieces by the heavy truck traffic during the present season. Colorado had this and the forces of nature as well to contend with.

When the spring of 1918 rolled around the roads of this State were in generally good condition. Composed for the most part of a heavy gravel in the mountain districts, mixed in with patches of adobe, the range highways passed through the winter season in generally good shape, the snow very frequently serving as a binder which really made the highways better.

In the eastern section of the State where the roads for the most part consist of gravel-surfaced highways, the same statement was true and until the year was well under way the State highway department and the county commissioners generally anticipated a comparatively light season of maintenance.

MACHINERY BOUGHT IN ADVANCE.

With the war in mind, however, general preparations had been made to meet unusual conditions. Thus many of the counties had taken up the subject of road machinery for the first time and heavy purchases of graders, scarifying machinery, trucks and other labor-saving devices were made.

Investigations into comparative costs had shown that the four-horse grader was an efficient unit on the plains, while six horses were sufficient to carry the burden of toil on the heavy mountain grades.

These machines linked up with the tractors of the State highway department gave the road officials a dependable battery of equipment with which to face the year's campaign and certain it was that last spring found Colorado better equipped for road building than at any time in past history, despite the fact that every indication pointed to a sharp curtailment in the labor available for this work.

What followed is one of those chapters in road building which can not be foreseen and the full meaning of which can only be appreciated when the book is finished.

HARD STORMS DESTROY ROADS.

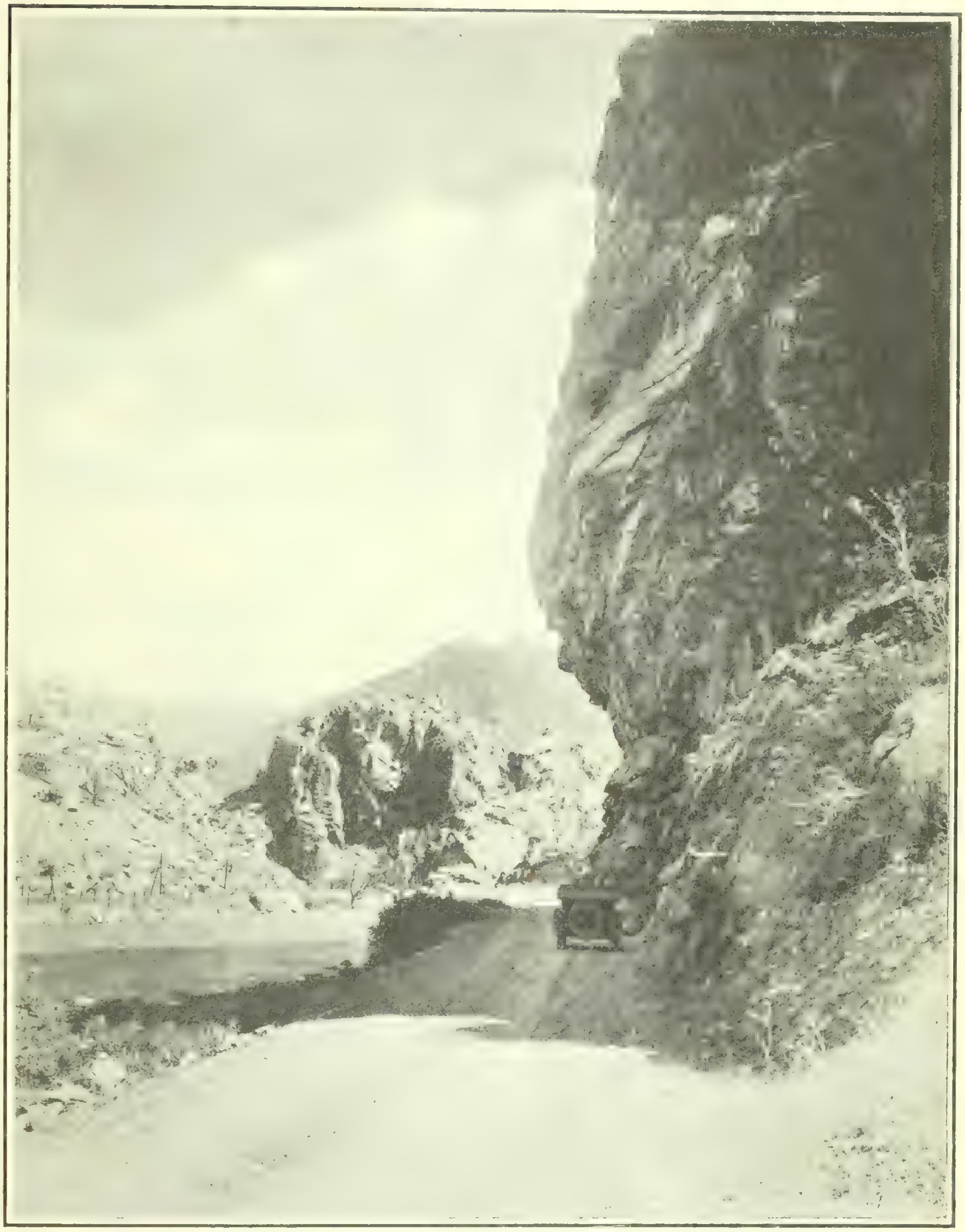
To begin with, an abnormally early hot-weather spell set in in the mountain country. Snow sheds which ordinarily carry their moisture well into late summer were released in June and by July the steady drainage of the higher peaks had settled down into a virtual flood. In every mountain district of central Colorado the rivers reached the highest levels of 30 years' tabulation, sometimes exceeding the memory of the ''oldest inhabitant'' and at once devastation of the highways began.

Bridges which had survived the highest waters of other years were torn from their bases and tons of metal and timber were carried downstream by the savage onslaught of the waters. Highways tucked away on the shelves of the hills were buried under the steadily rising streams, miles of road were washed out and from every county arose a call for aid from the State highway department.

Colorado's annual road appropriation amounts to only $80 per mile and naturally the sum was not enough. But the task was to be done and State and county officials set their teeth and went to it. Crews were temporarily called off construction work and put on maintenance. The counties scraped together every cent they could raise and sent men out on the roads. Within a short time the imperative demands were met and the roads were opened for traffic. Later, as opportunity offered, aided by a natural return to usable conditions as the sun got in its work, the less urgent conditions were taken in hand.

TEMPORARY REPAIRS WIPED OUT.

All might have been well had nature been content. But the old lady was not in a smiling mood and frowns were followed by tears. In midsummer, contrary to all past experience, fall rains set in and for weeks the State was deluged by a steady downpour.



ROAD ALONG THE UPPER ARKANSAS RIVER, NEAR SALIDA, COLORADO, BLASTED FROM SOLID ROCK AND COMPOSED CHIEFLY OF DISINTEGRATED RED GRANITE.

Out went the temporary repairs on the roads, down went the bridges, and in a fortnight not only had the repairs been wiped out but material damage had been added in the eastern section of the State which had escaped the troubles of the earlier season. Altogether fairly close estimates place the bridges lost at 125, while a conservative estimate of the total damage done amounted to $500,000.

On top of this the war had taken most of the younger road builders, the farmers needed every man they could get to harvest crops, and such labor as could be secured was of the kind which gives only about 50 per cent efficiency, requires a high wage, and finds fault at every possible occasion with every phase of his work.

Naturally the situation was not a pleasant one and to make it less so, commercial arteries of the utmost importance in the transportation of foodstuffs were among those most seriously damaged. Immediate attention was given these roads, with the result that the continuance of the rains made necessary reconstruction as often as two or three times on some stretches which have never suffered in the past.

Waterspouts cutting through arroyos were responsible for this, and as there are miles upon miles of road in Colorado which still follow the old freighting routes because such routes have been passable and funds have been needed elsewhere, it followed that in many cases new locations had to be made.

This, then, has been the situation in Colorado during the year, a situation which has been constantly aggravated by the fact that an intensive campaign for the development of motor truck transportation in this state has resulted in the formation of 100 new motor truck lines with the subsequent addition of hundreds of heavy motor trucks.

On top of this the added cost of passenger travel on the railroads resulted in the early part of the season in an actual and heavy increase in passenger travel on the roads despite the war. Travel generally was less, but the roads drew more than their share on the basis of past years, and everywhere in the State there was a constant demand for maintenance and improvement.

The cost of road work took an enormous jump. In one case that of the Federal aid project on the Jarr Canyon road, the construction work exceeded the estimates by 70 per cent, and in every instance there was a very marked rise in prices due to labor and cost of materials.

LOCAL ROAD MATERIAL SUPPLY.

The fact that Colorado has so much natural road material of the finest quality was in our favor and comparatively little use of the railroads was necessary. A good general supply of culverts was on hand and the type of steel used in most bridge work in the State was obtainable. Box culverts were used in some instances, but for the most part it was found possible to keep maintenance to standard.

The forethought exercised by county officials in purchasing machinery served to very marked advantage in the work and in consequence of this provision, together with a very general increase in road levies made last November, Colorado's highways are to-day open for travel and at the present moment generally better than they were even at the opening of the season.

Just now the question which is most disturbing State road officials is that of the future. Toward the end of the season there was a very marked decrease in passenger traffic, which has reached probably a diminution of 50 per cent already and which will probably continue on a downward curve until conditions brought about by the war changes. But the motor truck travel is showing an increase, and, as all road officials know, one motor truck is more to be feared than 50 passenger cars.

PLANS MADE FOR THE FUTURE.

Plans for the government of this traffic as now outlined by the State department include the introduction before the legislature of traffic regulations with stiff penalty clauses attached, which will give this office power to regulate width of tires, capacity of load depending upon character of road and speed of travel.

Other bills looking to an increase in the highway fund which will enable the department to meet the Federal aid act without dipping into the present appropriation will be drawn up, and finally every county commissioner in the State has been urged to maintain his road levy at either the present figure where it is already high or to increase it where it is below the average.

The department in these instances is proceeding upon the theory that restricted railroad transportation will add materially to the volume of traffic upon the roads and that adequate maintenance will be essential, in view of the fact that every nerve is now being strained to the utmost development of the enormous natural resources of the State, including radium, tungsten, the metalliferous ores, stock, produce, sugar, coal, and manufactured products.

This can only be accomplished in the coming year by an increased use of machinery on the roads to offset labor shortage, by the use of home manufactured road material to offset transportation restrictions, and finally by larger funds to meet increased costs.

All of these conditions have been discounted already and unless the State has another abnormal season such as the past one inflicted upon it, Colorado will "carry on" with all of the other States of the Union. Should 1919 imitate 1918 then we will simply have to go further than our situation will allow us to, but the roads will be kept open right down to the finish.

Little Maintenance Work Possible in Kentucky and Roads Suffer.

By RODMAN WILEY, Commissioner, Department of Public Roads.

THE majority of the main highways of Kentucky are built of water-bound macadam. Their condition in the spring of 1918 was bad, as many holes and raveled sections had developed; but on the whole there had been no actual breaking through of the surface, which was due principally to the excellent foundations.

The roads at this time are worse than they were in the spring. Very little repairing has been done and no organized maintenance has been possible. This department has repeatedly urged the counties to repair the roads but the results have been most unsatisfactory.

No law has been in existence allowing the department to enforce maintenance previous to this year and so far as this department is concerned we will not have power to force the counties to maintain their roads until next year.

The labor problem has not been met. Work on a large scale can not be attempted. Convicts have been used as much as possible and we have, this year, used as many convicts as the law permits money to be expended in doing work in that way.

We have met the material problem by using local material whenever possible or else by simply grading the roads and leaving the metal work for future time.

COUNTIES PURCHASE MACHINERY.

No special labor saving devices were developed. The department purchased a steam shovel for convict labor work, as well as purchased and used as many trucks as were needed. Many of the counties also purchased trucks and other modern road machinery.

Costs were from 25 to 35 per cent higher than in previous years but most of the contracts were old ones, let previous to the war and the State law permitted no adjustment of prices, consequently there has been some litigation and a general disarrangement of construction work as contractors did not care to operate at a loss.

Traffic increased considerably due to transportation of automobiles and automobile trucks to the South over the roads rather than by rail. Truck and wagon traffic increased because of the exceptionally large crops of food products and tobacco. The traffic increase during the spring, summer and fall was about 25 per cent for wagons, 50 per cent for automobiles and 50 per cent for trucks.

There is no special necessity for making provisions for keeping roads open this winter as we do not anticipate any great volume of through hauling and snow conditions are mild as a general thing.

If it had been possible under war conditions to allow shipment of bituminous materials for surface treatment of macadam roads, it would have decreased the need of stone shipments in cars. One car of oil used for surface treatment will, in a number of cases, save as much as 50 cars of stone which would have to be used for resurfacing. Under all circumstances the use of local materials should be encouraged. I would suggest also that legislation be enacted to allow all men confined in State penitentiaries and county jails to work on the roads. The use of labor-saving machinery should be strongly urged, elevating graders, steam shovels, stone spreaders, car unloaders, trucks and such things should not only be used so as to reduce the cost of work, but by using such things work can progress with a minimum number of men.

New York Restores Broken Highways While Maintaining Traffic.

By FRANK W. BRISTOW, Superintendent of Maintenance, New York State Highway Commission.

"MAIN Street" in any hustling community will serve to illustrate the relative importance of route 6 in the system of State-county-town highways in the State of New York.

Beginning at Buffalo, the foot of navigation of the Great Lakes, this route traverses the State from west to east, paralleling the New York Central and the West Shore Railroads and also the Barge Canal for a distance of 300 miles to Albany at the head of navigation of the Hudson River, where it joins two through north and south routes paralleling the same railroads and the Hudson River for a distance of 150 miles to New York City.

It has been estimated that of New York State's 10,000,000 population, 90 per cent are included in a belt 10 miles wide paralleling the New York Central Railroad, so that clearly route 6 and its southerly prolongation is the main artery connecting the centers of population to which the balance of the complex network of improved highways are but tributaries.

It is a "highway of military and national economic value" as defined by the United States Highways Council.

This route is improved throughout, usually with broken stone bituminous macadam about 16 feet wide and about 6 inches thick, the foundation soil being generally clay, and the topography varying from gently rolling to very flat.

This road has been and is still being extensively used by the military authorities of the Federal Government in transporting fleets of Army motor trucks frequently loaded to a gross load of 8 tons, of which two-thirds of the load is concentrated on the rear axle, which fleets vary from 30 units to nearly 100 in number, and are sent across the State several times a week.

About the 1st of April of this year the headquarters office of this department was, without any preliminary warning, suddenly bombarded by a torrent of complaints from automobile and municipal officials and also of our own engineers located along the western 100 miles of this route, between Buffalo and Auburn.

EMERGENCY MEASURES REQUIRED.

The substance of these complaints was that the bottom had dropped out of long stretches of this important road and that numerous long sections were impassable to traffic.

Prompt instructions were given to the maintenance men throughout the sections involved to proceed immediately with such temporary repairs as would at least make the road passable. At the same time careful inspections were made to determine the location and extent of the broken sections, and it was found that the total length of road requiring reconstruction was approximately 40 miles, composed of numerous short sections, of which about 25 miles were segregated in the western 100-mile length extending between Buffalo, Rochester, and Auburn. An emergency appropriation of $1,000,000 was quickly passed by the legislature to provide funds for these repairs, plans were made, and proposals invited for restoring a considerable portion of these broken sections with concrete pavement, to be 18 feet wide and 7 inches thick, our investigations having led to the conclusion that the failure was due to foundational weakness and also because the roads were called upon to bear a destructive load at the time when the frost was coming out of the ground.

While the thin macadam crust might have bridged over the unstable foundation soil for occasional heavy loads, in our opinion the truck traffic with the numerous separate units following each other at regular short intervals caused the macadam to weave, thereby puddling or pumping the moisture to the immediate subgrade and so decreasing its stability to the extent that the macadam crust soon broke through under the concentrated wheel loads, resulting in churning together a mixture of soft mud and broken stone fragments to a considerable depth, rendering the affected section practically impassable.

These conditions were promptly temporarily remedied by smothering the areas affected by any materials immediately available which would give increased stability, as broken stone, gravel, or even ashes and similar refuse, at the same time forming lateral drains whenever possible to expedite drying out these mud holes.

HIGH-COST CONCRETE CONSTRUCTION.

Of the proposals received for concrete reconstruction one project providing for building 3½ miles, composed of several sections of various lengths within a distance of more than 7 miles, was awarded at a cost approximating $33,000 per mile, the mixture to be 1 part cement, 1½ parts sand, and 3 parts broken stone, all materials being purchased by the State subject to contractor's shipping directions, so as to assure priority shipment privileges.

The proposals submitted in connection with the other projects at this time were deemed exorbitant, being greatly in excess of our estimates, and they were accordingly rejected as on that basis the funds authorized evidently would not cover the work necessary, so that a change in the proposed type of reconstruction became advisable.

Proposals were again invited upon six projects averaging 3 miles length of construction, each consisting of numerous sections of new work varying from 300 feet in length to about 1 mile in length and providing for leveling off and consolidating the existing broken road, forming new earth shoulders, laying a heavy foundation course of crushed furnace slag 6 inches compacted thickness, upon which was to be laid a broken stone bituminous macadam surface, penetration method, 2 inches rolled thickness, the surface to be 16 feet in width, the binder generally being refined tar applied at the rate of 1½ gallons per square yard in two applications, the top stone having been partly filled with stone chips before the first application, with the result that the six projects aggregating more than 18 miles were awarded to five distinct contractors at an average cost of $21,000 per mile, the requirement in each of these contracts being that the work be carried on in such a manner as to allow traffic the use of one-half the width of the road at all times, a pay item being inserted in each contract for maintaining traffic.

Tar binder was selected because at the time of preparing the plans the assurance of its delivery was more certain than for asphalt. Slag for foundation was selected because it is cheaper than stone.

HOW THE WORK WAS CARRIED ON.

These contracts were promptly started and progressed at the rate of about 1 mile completed work per month, with a minimum interference with traffic so that the pavements were practically completed by the middle of September.

The concrete was laid, one-half the width at a time, the middle joint having a triangular key way moulded into the section first laid, this being intended to so tie the two halves together that in the event of movement under frost action or otherwise, the two halves would move together and uniformly. In the case of the new macadam work where the width of the right of way permitted, a side road was provided, but where the width or topography would not permit of this, the stone was delivered in piles on one side of the road, the bottom course being kept filled and rolled as near to the end of the spread as practicable, generally about 100 or 200 feet. In finishing the top course, the usual practice was to pour half width at a time, when one side was completed turn traffic upon same, and proceed with the other half.

In some cases, however, the plan was adopted of closing off traffic for a period of 30 minutes, during which time a section of top course would be completed, then opening the road to allow the accumulation of vehicles to pass, requiring say about 10 minutes, again closing, and repeating the same operation.

By reason of the tar binder being somewhat slow in setting, particularly in warm weather, the effect of permitting traffic upon the freshly poured surface has been to produce a final surface that perhaps is not as smooth as could be desired.

All unloading of carloads of stone, slag, sand, etc., was performed by elevators into bins and practically all materials were hauled from bins at railroad delivery points to the roads by motor trucks. The application of binder was by mechanical pressure distributors. Grading was done as much as possible by scrapers, and the entire construction program executed so far as feasible by other than hand labor, labor being both scarce and inefficient, and demanding wages of from 40 to 50 cents per hour.

RESURFACING BY DEPARTMENT FORCES.

In addition to the seven contract projects before enumerated, an aggregate of 18 miles composed of various short sections, usually in distant portions of this main through route, were resurfaced or reconstructed with bituminous macadam, using departmental equipment and forces in our direct employ, this work varying from 3 to 7 inches or more in thickness, depending upon the necessity for foundational reinforcement, the same also being laid one-half width at a time or if full width by temporary closing to traffic or by providing a side road, so as to interfere with traffic as little as practicable.

It may be of interest that the above direct departmental work included over 2 miles where the repairs were made by utilizing the labor of convicts from Auburn State Prison, supervised by our foreman.

This gang of prisoners, averaging twenty in number, were transported every working day from the prison accompanied by a guard, to and from their work, a distance not exceeding 8 miles each way, in a 5-ton motor truck This department furnished a commissary camp and these men were given two hot meals daily on the job; for their services this department paid to the prison department $1 per day for each man, including the two or three men at the mess camp. This payment included both transportation and the meals referred to. The service of this gang compared favorably with force labor.

Soon after the completion of the macadam, the bituminous surface in several instances appeared rather bare and open after being subjected to traffic for a brief time, and it was deemed prudent to seal it by a light surface treatment of cold application tar applied at the rate of one-quarter gallon per square yard with either sand or screenings for cover.

HOW TRAFFIC WAS KEPT GOING.

The traffic during the past summer season has been above the normal. In addition to the military truck traffic, there was the usual touring and commercial traffic, together with an enormous volume of traffic due to new pleasure and commercial motor vehicles being delivered by being driven across the State under their own power.

While a passable way was maintained for traffic throughout the work under construction, it was of necessity in places but a single track way, involving leaving at intervals of not more than a quarter of a mile either gaps in delivery of construction materials or in some instances especially graded wider spots to permit opposing traffic to pass. Existing farm driveways also served well as turnouts. Warning signs to run slow and also conspicuous signs marking passing places were found necessary.

Also through the agency of touring information bureaus, traffic was encouraged to follow detours which diverted an appreciable amount of traffic around instead of over the work in progress.

Costs of this work were more than double those prevailing on similar construction prior to our advent into the world war, but urgent necessity is the justification for paying such prices.

We would have preferred our new construction to have been continuous within a contract limit instead of being broken into several shorter sections, but in harmony with the spirit of the time we endeavored to conserve transportation, labor and materials and only restore sections which were actually broken.

Of the million dollar appropriation previously referred to, the Commissioner allotted $50,000 which, as far as necessary, will be expended in keeping certain main routes which have been selected by representatives of the War Department open during the coming winter. The length so selected is between 500 and 600 miles of improved highways.

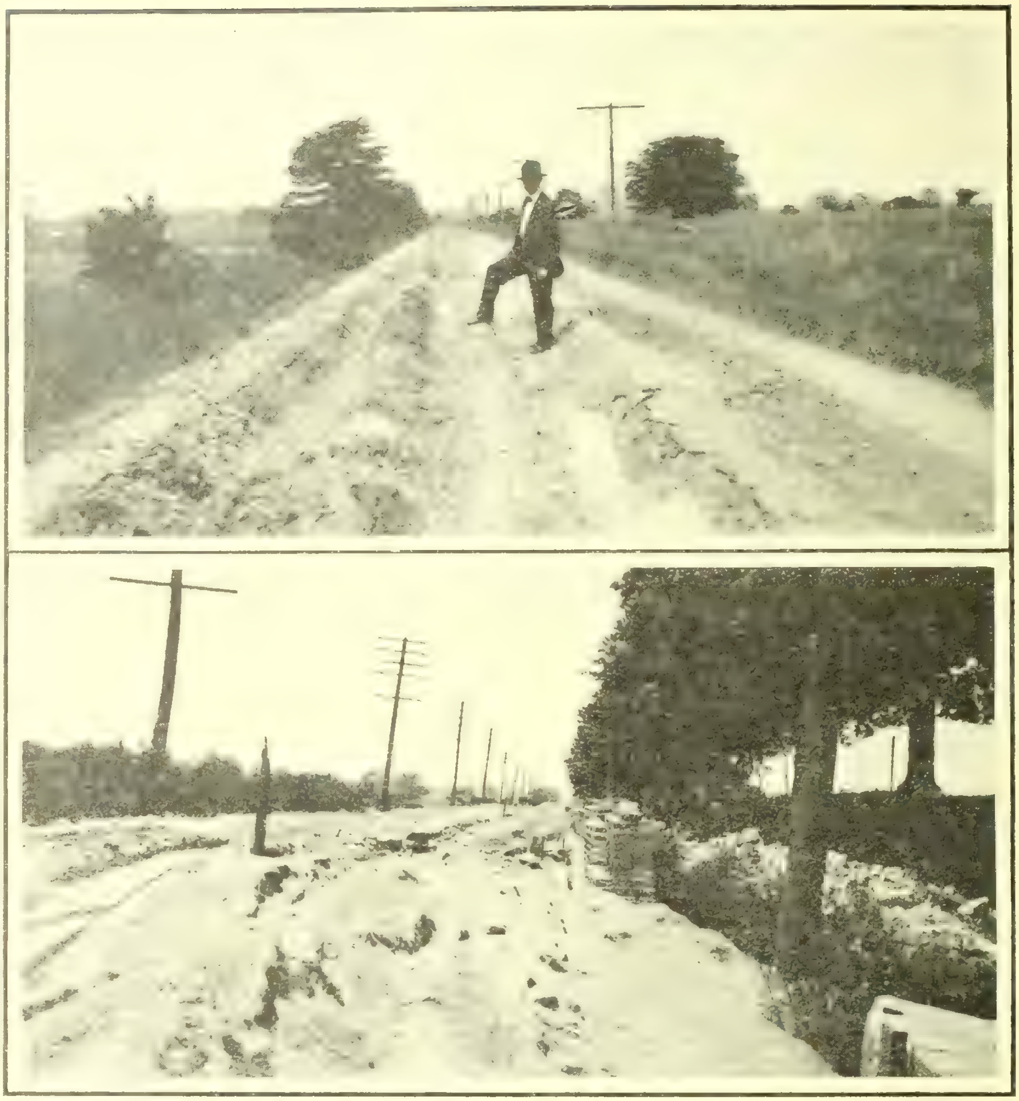
While the precise details for handling this work are not fully decided, it is expected to take advantage of the experience of neighboring States which have previously encountered similar problems.

How Ohio Handled Important Roads Broken Down by Huge Traffic.

By CLINTON COWEN, State Highway Commissioner.

WITH a bright, cheerful day, the thermometer at a guess standing at about 60° in the shade, with many varieties of fall flowers yet unaffected by the frost, I am forcibly reminded of the contrast of weather conditions of one year ago. On November 22, 1917, I reported at Toledo with the chief engineer of this Department to meet Mr. Osterman, Field Secretary of the Lincoln Highway Association, Captain Butchers and Mr. E. W. James of the Bureau of Public Roads, to accompany them across the State to search out the best possible route for Government truck service passing through the northern part of the State to Pennsylvania. The day was unseasonably cold and blustery, with a substantial fall of snow for the time of year. The ground was frozen. Altogether, the prospect of making a journey across the State was one of severe business unalloyed with any pleasure that the condition of weather might afford.

Mr. James asked me very pointedly what I proposed to do with a certain class of roads that seemed certain to him would yield under continuous heavy traffic of Government trucks that were then about to start from Detroit to the East. The thought of Mr. James seemed to be that during soft and wet weather the severe strain to which our roads would be subjected would cause many to break up and disintegrate. This, indeed, did happen, but not until the approach of spring, nor was it confined to any particular type of road. It was rather due to the character of construction that was not intended for the unusual test of heavy trucks passing rapidly in succession, each following closely in the track of the preceding truck.



WAR-TIME DESTRUCTION OF OHIO ROADS. TOP—TAR MACADAM ROAD NEAR SANDUSKY, BROKEN DOWN BY HEAVY TRUCKING OVER A WEAK FOUNDATION. BOTTOM—BRICK ROAD IN SUMMIT COUNTY, DESTROYED BY HEAVY TRUCKS AND REPAIRED WITH 8-INCH CONCRETE FOUNDATION, MONOLITHIC TYPE.

SNOWS MAKE UNUSUAL CONDITIONS.

But long before our sorrows commenced with road failures we were early confronted with unusual conditions. Beginning with November 22, the ground was scarcely exposed for a day until the final break up in the spring. Snow storm after snow storm, adding its might to the original with the unusually cold weather that prevailed and continued almost up until March made highway travel in the northern part of Ohio on many roads quite impossible. This brought about a condition unlooked for and one which the State was utterly unprepared to combat because of lack of equipment to take care of such a condition and because the obligation of taking care of it seemed to rest with township authorities.

Realizing that the Government needs were imperative and that truck trains must move, we carried into effect the request of the National Council of Defense to provide a means for Government transportation. Much credit for our success was due to the county surveyors and the township trustees through which the road runs. None of the county surveyors and but few of the township authorities neglected to use their best efforts in complying with our request. It would have been practically impossible for the State to have handled the work single handed, as the law had not made provision for such conditions.

With the congested condition of the railroads and their inability to promptly handle supplies that were needed in almost every community, it became necessary after opening up main arteries for travel to open up the lateral roads in order to reach the possible outlet to and from markets and villages. The amount of traffic these highways must sustain is apparent. The truck traffic was practically constant with all additional vehicles conceivable using many of the roads.

TRAFFIC DESTROYS HIGHWAYS.

Not only did the truck and automobile traffic greatly increase, but burdens were placed upon them clearly in excess of what any ordinary road would be expected to carry. This great increase in traffic was, of necessity, confined largely to such roads as had been prepared by the removal of snow drifts, etc.

While the unusual depth of snow, due to the long, cold weather, caused much inconvenience by obstructing our highways, we had the advantage of the frozen condition of the roadbed which was sometimes rough but nevertheless passable. However, when the spring came the greatly increased loads and amount of traffic that had become accustomed to follow certain roads, together with the softening of the frozen ground to the very bottom, caused many of our main highways to break down under this heavy strain. Roads that had carried normal to heavy traffic for years were wrecked in a few days.

The problem of placing these roads in condition for use and to maintain them for traffic until the weather came on which would permit the destroyed roads to be rebuilt was no small one. In some places car loads of material were dumped on the road merely as a temporary means of carrying traffic until a more favorable time came to detour the traffic and rebuild the road. Finally the good weather of summer came on and the heavy through traffic which had concentrated on a few of the main highways was scattered or diverted over the secondary and earth roads to give us an opportunity to rebuild the main roads destroyed in the spring.

REPAIRING THE IMPORTANT ROADS.

To accomplish all this work meant no little anxiety and trouble on the part of our road officials. The project must be financed, the labor problem met and the shipping conditions of the materials had to be given individual study in order to obtain what was desired and accomplish results.

The most important routes which required our attention in Ohio were the Government truck route leading across the northern part of the State from Toledo to East Palestine and the National Road between Columbus and Wheeling. The latter I would especially mention. Labor was scarce and inferior and the cost, as all know, was two or three times the amount paid during normal times. On account of these abnormal conditions and the great demand for the improvement of this road, it was felt that legal technicalities should not prevent the carrying out of a project that seemed necessary to promote Federal assistance in transporting army trucks and materials from the west. Accordingly, we brushed aside legal technicalities that might be considered of importance in normal conditions, and proceeded to build 14 miles of brick road in Musingum County by force account contract. The estimated cost of this work was $488,500. The final cost will possibly exceed the estimate by about 20 per cent. This is already accounted for in the increase in freight rates and the amount of material that would be used in a force account job in excess of one under contract. The work was completed in about 180 days. Our success was largely due to the use of convict labor. We found it efficient and it no doubt had a stabilizing effect on all other labor connected with the work. In addition to this brick road, we also completed this season more than 10 miles of macadam road on the National Road in Guernsey County. This was also done by force account and largely by the use of prison labor.

Rhode Island Replaces Sections Wearing Out with Better Type of Roads.

By A. L. ATWOOD, Chairman State Board of Public Roads.

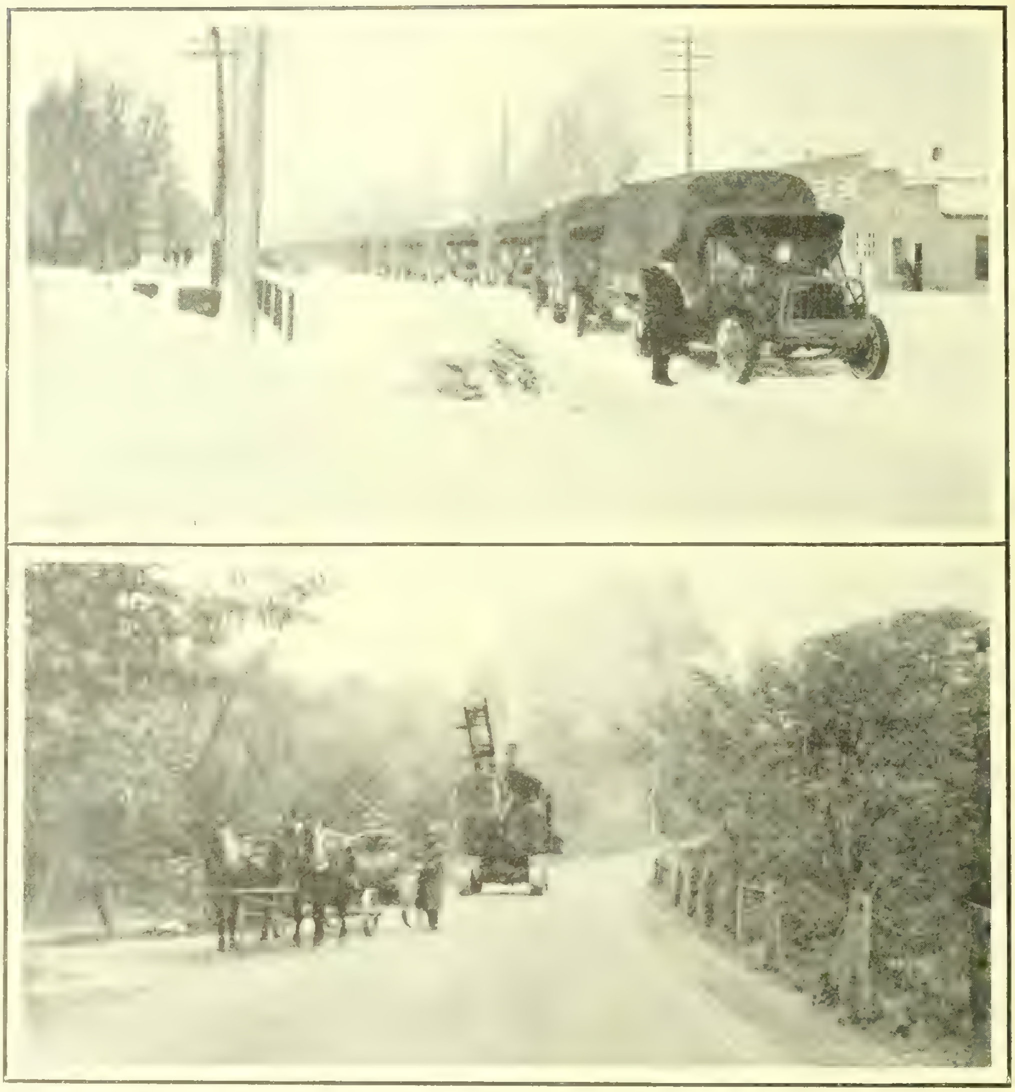
RHODE ISLAND'S expenditures for State road and bridge work during 1918 will be approximately $600,000, of which $500,000 will be for roads and $100,000 for bridges. Our available road fund is made up of approximately $275,000 secured from motor vehicle registrations and approximately $225,000 from a State highway tax of 3 cents per $100 upon the ratable property of all towns and cities in the State. The road funds from both sources are availabe only for maintenance and reconstruction.

The State highway system of Rhode Island is made up of 325 miles of road, of which 208 miles are of plain or waterbound macadam and 117 miles are bituminous macadam or bituminous concrete.

The maintenance of our plain macadam roads has been a serious problem for a number of years. Many of these roads were built from 10 to 15 years ago according to the provisions of our original State highway law, which restricted the width of metalled surface to 14 feet. These roads also were frequently paid for from appropriations which were too meager to allow of proper foundations and drainage structures or to allow of desirable grades and alignment. Many of these old macadams, furthermore, are located upon our main trunk lines and are called upon now to carry a mixed traffic of from 250,000 to 800,000 vehicles annually. The reconstruction of wornout macadams was taken up in Rhode Island at a later date than was the case in the majority of

States which began State road building at an early date and constructed in consequence a great deal of plain macadam. The financing of reconstruction work also since it was commenced has not been sufficiently liberal to permit carrying out the work as rapidly as would have been desirable.

The conditions surrounding the building and reconstructing of our plain macadams as described previously have brought about a serious condition as far as the maintenance of these roads is concerned. The unusual conditions now surrounding all construction work are naturally particularly serious in their effect upon the maintenance of our old wornout macadams.



TRAFFIC DEMANDS ON OHIO ROADS. TOP—TRUCK TRAIN AT WOODVILLE, WINTER OF 1917-18. BOTTOM—24-TON STEAM SHOVEL MOVING OVER A MONTGOMERY COUNTY HIGHWAY.

OLD MACADAMS RECONSTRUCTED.

During the past spring when frost action upon our roads was at its maximum, there were a number of sections of old waterbound macadam which were next to impassable for heavy vehicles and which were difficult even for light touring cars to negotiate. In view of the importance just at that time of our main highways in relieving a serious congestion of railroad freight, these prohibitive sections of highway were deplorable. It was manifestly impossible with the funds at our disposal to reconstruct according to modern standards all of the bad sections of plain macadam, but we have succeeded in relieving conditions very materially by reconstructing with proper foundations and relatively permanent surfaces many of the sections which were practically prohibitive to travel during winter and spring thaws. We have also placed foundations upon a number of bad sections and have placed over these foundations a temporary surface of gravel or of plain macadam until such time as our funds and more propitious conditions make practicable the laying of more durable wearing surface. We have taken care of still other prohibitive sections by drainage projects only.

Our plain macadams have as a consequence of our work during the past season been lessened in mileage as a result of reconstruction and have been brought upon the whole to much better condition to carry travel during the coming winter than was the case one year ago. To be sure, we still have sections which are far from good, but these sections are fewer than they were.

BITUMINOUS ROADS HOLD UP WELL.

The maintenance of our bituminous macadam roads and of our bituminous concrete roads has been a comparatively simple task. The roads of this type came through the winter in fully as good condition as has been the case in past years in spite of the great increase in certain localities of motor-truck travel because of the unusual military, naval, and industrial activity, and because of conditions surrounding the movement of rail freights. These roads are now in very good condition and perfectly capable of carrying the travel to which they will be subjected during the coming winter.

Our heavier work of reconstruction has, of course, been handicapped more or less by the unusual conditions prevailing. We have, however, been able to carry all of this work along without serious delay and without the necessity for stopping any of it. By far the greater number of jobs started will be completed and those not completed will have progressed so far that completion will be a simple matter next season and so that travel can without serious inconvenience pass over the work during the winter months.

In carrying out maintenance work we made an earnest and successful endeavor to reduce our normal use of bituminous materials in accordance with the request of Federal authorities. The usual quantity of bitumens used by this department annually for maintenance work is about 700,000 gallons. In 1918 the quantity used for maintenance has been approximately 200,000 gallons. Many of our plain macadam roads had a considerable accumulation of bitumen upon their surfaces from a number of applications in past years. Roads in this condition were not treated this year, as is our usual custom, and we are able so far to see no serious result from the omission. It appears, however, that treatment of these roads next year will be imperative in order to avoid serious deterioration. It will, however, be possible, if the demand for reduction in use of bitumen still exists, to omit next year the treatment of some of the roads treated during the past year, and it will of course be unnecessary to treat the plain macadams which were reconstructed this year.

STEAM IN PLACE OF MAN POWER.

The trying conditions surrounding construction work during the past year have brought about some changes in our methods of doing work and have necessitated the greatest care in the planning of our work. Steam shovels, for instance, were used for excavation work so uniformly shallow that under normal conditions we would consider handwork only. The use of steam shovels was also further extended than is customary to the handling of materials from storage piles in order to save labor. Much handwork and team hire was also avoided by the employment of scrapers hauled by trucks or light steam rollers.

Our State highway law does not permit us to remove snow and ice in order to keep our road open during the winter months. All work of this nature, under the terms of our law, is done by town or city road authorities. The snow problem is not nearly as serious in Rhode Island as it is in States farther inland. Ordinarily we experience few falls of snow which render our roads impassable for long periods, even though no work of opening the roads is done.

Existing conditions made necessary a considerable change during the past year in our method of laying out our work. Labor shortage made necessary a very careful study of labor conditions immediately before work of any sort was actually started. The desire to have our main trunk lines passable at all points during the entire year caused us to spread out our work more than has been our custom and in many cases to adopt temporary surfaces over foundations placed to take care of soft places. Our policy of carrying out our work did not include the enhancing at the earliest possible moment of the comfort of high speed travel. The repair of sections of road which were simply inclined to be rather rough at high speeds gave way under our plan of work to the repair of sections which at times were so soft that travel over them was virtually impossible.

We did not attempt to make plans for work extending over long periods. Conditions were changing rapidly throughout the construction season. New Federal restrictions were imposed from time to time, the supply of available labor fluctuated, and railroad freight embargoes were frequent. In laying out our work therefore we adopted a policy which during normal times might well be termed a "hand-to-mouth" method of doing work. Nothing was started until it seemed probable that it could be completed or at least carried to such a stage that travel could pass over the site of the work during the winter and early spring.

Now that the construction season is over and a retrospective view of our work is possible we are agreeably surprised to note that the numerous difficulties which were apparent early in the season were not as insurmountable as they then appeared. It seems to us that under conditions as they are we must go slowly in planning our work and that no project should be started until a careful study has been made in order to ascertain its necessity and and also to determine the probability of carrying it to a successful conclusion.

It is not our belief that road work should be stopped. Our good roads should be maintained from the standpoint of economy and our very bad roads, expecially those sections upon important main through trunk lines, should be made serviceable for the traffic which is so necessary to our industries at this time. We feel that road improvement is of greater importance now than it ever has been before, but we perceive also the necessity for looking at the road problem from the standpoint of military and industrial necessity.

Costs Shown Under Washington's State Highway Maintenance Law.

By GEORGE F. COTTERILL, Chief Engineer, State Highway Department.

DURING the six years preceding 1917 the Washington program of "Good roads" had resulted in about 1,250 miles of construction along the primary State highway routes, of which 330 miles had been improved by the counties under the permanent highway law. The counties had also constructed more than 400 miles of permanent highways on secondary State highways and other main lines of travel. Without definite figures it is a safe estimate that at least an additional 350 miles of main county highways had been improved of like character with permanent highways from the proceeds of county bond issues, road and bridge funds, district funds and by assessment district procedure.

Thus, there was by 1917 a total of about 2,000 miles of constructed primary State highways, permanent highways, and other roads of like character, representing an investment of at least $15,000,000 by the State, counties, and districts during the six years preceding. This progressive program was authorized for continuance of construction during 1917 and 1918, assuring the further investment of at least $5,000,000 and the addition of about 500 miles to the list. This will make altogether about 1,500 miles of constructed primary State highways and about 1,000 miles of other main county lines of travel improved to permanent highway standards of construction by the end of 1918, or a total of 2,500 miles of improved main highways, outside the cities, throughout the State.

MAINTENANCE LAW OF 1917.

The legislature of 1917 was confronted by a situation in which the accumulated 800 miles of constructed primary State highways were under obligation of maintenance by the State Highway Department from a construction percentage fund yielding only $75,000 annually, while the counties were provided with a construction percentage fund of $75,000 plus an apportionment of surplus motor-vehicle revenue yielding $225,000 and increasing annually, or at least a $300,000 annual total with which to maintain about 1,200 miles of permanent highways and other county roads of like character. It was apparent that the provision for the primary State highways was grossly inadequate, while that for the county permanent highways and other roads of like character had proved ample. Facing the alternative of doubling the maintenance percentage from the public-highway fund for application to primary State highways, the legislature squarely placed this maintenance as a first claim upon the funds derived from the motor-vehicle surplus revenue, working out the 1917 law with the following basic features, viz:

(1) All highway maintenance to be under direct county administration, with State Highway Department regulative control and reserve power to enforce standards of maintenance on constructed primary State highways.

LARGE SUM MADE AVAILABLE.

(2) Abolition of former 7½ per cent of public-highway fund for maintenance, releasing it for construction program; increase of motor-vehicle fee schedule by about 50 per cent, so as to produce a surplus over license administration expense, estimated to realize $425,000 in 1917 and $675,000 in 1918, for apportionment to county permanent highway maintenance funds in addition to the 5 per cent of permanent highway levy, or $75,000 annually. (This had the net effect of providing $500,000 for 1917 and $750,000 for 1918 to support the increasing maintenance program, as compared to $375,000 in 1916, $200,000 in 1915 and much smaller amounts in preceding years.)

(3) This ample maintenance provision is made applicable for expenditure by the county authorities only for the maintenance and repair of (*a*) constructed primary State highways; (*b*) permanent highways (i. e. highways constructed under the permanent highway law); and (*c*) other highways of like character (i. e., highways along main lines of travel improved by counties from any fund to construction standards equal to requirements of permanent highway law); also (*d*) for equipment for the maintenance of the preceding classes of highways.

(4) The expenditure of these county permanent highway maintenance funds is safeguarded by requirement that county auditors shall only issue warrants on vouchers approved by the engineer in charge and allowed by the board of county commissioners for the sole purpose of maintaining and repairing the highways of the described classes and their maintenance equipment.

CAN USE CONSTRUCTION FUND.

(5) In the event that there is not sufficient money to the credit of the permanent highway maintenance fund in any county to maintain the constructed primary State highways within the county, the county commissioners shall expend any necessary amount of the county credit of permanent highway (construction) fund to accomplish such maintenance, and if this be not sufficient or available they shall pay the remainder from the general road and bridge fund of the county. By these provisions the 1917 law squarely lays down the principle that the constructed primary State highways must be adequately maintained even at the expense of a construction fund. Maintenance of the roads we have stands ahead of new construction.

STATE OF WASHINGTON—MAINTENANCE AND REPAIRS—PRIMARY STATE HIGHWAYS.

Expenditures June, 1917–May, 1918 (inclusive); compiled from County Engineers' Reports to State Highway Commissioner.

SEGREGATED BY COUNTIES.

County.	Period, June–December, 1917.			Period, January May, 1918.			Combined year.		Special notes.
	Mileage.	Expenditure.	Per mile.	Mileage.	Expenditure.	Per mile.	Expenditure.	Per mile.	
Adams	25.28	$422.63	$16.72	25 28	$489.38	$19 36	$912 01	$36.08	Natural earth grade; light traffic.
Asotin	2.27	570 00	251.10	2.27	72.65	32.00	642.65	283 10	
Benton	34.67	2,779 98	80 18	44.67	12,471.74	279 20	15,251.72	359 38	Includes $7,000, washout repairs.
Chelan	7.00	100.00	14 29	15.13	1,502 50	99 30	1,602.50	113 59	
Clallam	76.24	5,674 12	74 55	76.74	14,792 50	192.76	20,466.62	267 31	Includes $2,500, auto equipment.
Clarke	18.04	1,426.09	79 05	18.04	6,323 84	350 55	7,749 93	429 60	Includes resurfacing north section.
Columbia	16.90	5,742 82	339 81	23 46	5,097 91	217 30	10,840.73	557.11	Includes extensive resurfacing.
Cowlitz	19 48	5,845 87	300.09	23.14	9,959 17	430 39	15,805 04	730.48	Includes $5,700, auto equipment.
Douglas	20.07	460 00	22.92	27 52	2,360.21	85 76	2,820 21	108 68	Includes $1,000, equipment.
Franklin	None reported.		....	1.91	15 93	8.34	15 93	8.34	Only nominal maintenance.
Garfield	5 78	1,161 56	200 96	5 78	4,517 24	781 53	5,678.80	982 49	Includes extensive resurfacing, equipment, etc.
Grant	20 44	1,253 00	61 30	21 03	1,736 92	82 59	2,989 92	143 89	
Grays Harbor	68 27	27,218 56	398 69	72 25	14,319 74	198 19	41,538 30	596 88	Includes extensive resurfacing.
Jefferson	31 84	4,773.28	149 91	31 84	2,794 32	87.76	7,567.60	237.67	
King	119.68	59,709.16	498 91	119.68	51,373.60	429 25	111,082 76	928 16	Includes extensive repairs, equipment, etc.
Kittitas	65 15	9,356 41	143.61	90.90	7,214 71	76.07	16,571.12	219.68	Includes snow removal, sprinkling, etc.
Lewis	77.90	2,673 34	34.32	77 90	9,580.39	122 99	12,253.73	157 31	Includes $4,000, south approach to Cowlitz Bridge.
Lincoln	39.45	10,206.20	258.71	39 45	3,784 99	95 94	13,991 19	354.65	Includes extensive resurfacing.
Mason	46 50	3,689.42	79 35	46 50	3,988.92	85.78	7,678.34	165 13	
Pacific	24 63	1,475 61	59.91	55 65	4,440 10	79.79	5,915 71	139 70	
Pierce	78 06	3,680 06	47.14	86 24	9,803.21	113 67	13,483 27	160 81	
Skagit	27.00	7,880 68	291 88	27 00	6,596 67	244 32	14,477 35	536 20	Includes new decking Skagit Bridge.
Snohomish	42 41	6,943 25	163 71	42 41	3,001 38	70 77	9,944 63	234 48	Includes $2,000, flood repairs, Silvana Bridge.
Spokane	93 63	9,642 61	102 99	95 88	6,610 63	68 94	16,253 24	171 93	
Stevens	8 91	300 00	33.67	8 91	1,166.72	130 95	1,466 72	164.62	
Thurston	45 63	2,501 91	55.03	56 53	6,245.20	110 48	8,756 11	165.51	Includes $1,500, equipment
Walla Walla	38 09	10,385 81	272.66	44 00	2,108 39	47 92	12,494 20	320 58	Includes $4,800, auto equipment.
Whatcom	8 07	407 40	50.48	21 06	2,370 39	112.55	2,777 79	163 03	
Whitman	63 53	13,683 03	215 38	65 31	14,824 62	226.99	28,507 65	442 37	Includes $16,000, equipment
Yakima	118 85	10,858 09	91.36	118 85	9,794 77	82 41	20,652 86	173 77	
State	1,243.77	210,829 89	169 50	1,385 33	219,358 74	158 34	430,188 63	327 84	

SEGREGATED BY TYPES OF PAVEMENT OR SURFACING.

Period.	(1) Brick pavement.	(2) Concrete pavement.	(3) Sheet asphalt.	(4) Asphaltic concrete.	(5) Bitulithic (warrenite).	(6) Bituminous macadam.	(7) W-B macadamized rock.	(8) Gravel surfacing	(9) Natural earth grade	(10) Bridges and trestles.	Total, all types.
JUNE–DECEMBER, 1917											
Counties	1	10	2	2	3	6	14	24	4	3	29
Road sections	3	20	3	6	4	13	40	108	12	4	213
Mileage	8.81	90 59	5 97	19.74	14 41	40 21	159 90	792 40	109 74	2 00	1,243 77
Expenditure	$9,456 51	$5,092 45	$326 03	$319 76	$2,978 50	$5,493 49	$25,333 79	$143,311 52	$11 043 37	$8 474 47	$210,829 89
Expenditure per mile	$1,073 38	$57.21	$54.61	$16 19	$206 70	$136 62	$158 43	$180 85	$100 63	$4 237 23	$169 50
JANUARY–MAY, 1918											
Counties	1	12	2	2	4	6	14	27	8	7	30
Road sections	3	24	3	8	5	13	45	115	20	10	246
Mileage	8 81	102 41	5 97	23.24	17.81	40.21	174 71	839 90	168 51	3 70	1,385,33
Expenditure	$3,352 32	$2,809 97	$36 52	$225 52	$3,748 29	$4,833 66	$29 536 06	$149 379 28	$8 434 02	$17,003 10	$219,358 14
Expenditure per mile	$380 51	$27 44	$6.12	$9 70	$210 45	$120 21	$169 06	$177 85	$50 04	$4 595 40	$158 34
COMBINED YEAR.											
Expenditure	$12,808 83	$7,902 42	$362 55	$545 28	$6,726 79	$10,327 15	$54 869 85	$292,690 80	$19,477 39	$24 477 57	$430,188.63
Expenditure per mile	$1,453 89	$83 65	$60 73	$25 89	$417 15	$256 83	$327 46	$358 70	$150 67	$8 352 63	$327 84

EXPLANATIONS AND REMARKS FOR COMPARISONS.

Figures include all expenditures upon entire highway for maintenance, repairs, equipment, and supervision.

(1) Brick pavement.—Large repair expense replacing broken sections due to settlement and other defects in original construction.

(2) Concrete pavement.—"One-course," "two-course," and "granitoid" types, 1 to 5 years' use, all costs pavement and roadbed.

(3) Sheet asphalt.—Only three sections in two counties 1 to 4 years use, mainly adjoining cities extending city streets.

(4) Asphaltic concrete.—Mostly new work, in first or second years' use requiring only nominal maintenance expenditures.

(5) Bitulithic warrenite.—High cost due to 6.11 miles warrenite north from Seattle ($783 43 per mile), also repairing washed-out section, Yakima County ($361 67 per mile), remainder cost $87 59 per mile.

(6) Bituminous macadam.—Includes all forms oil-bound surfacing by "penetration" system, sections in two to eight years' service.

(7) W-B macadam.—Includes all forms crushed rock surfacing except oil-bound, figures cover all upkeep and equipment charges.

(8) Gravel surfacing.—Figures include resurfacing several sections, approximating fair recurring average as applied to all.

(9) Natural earth grade.—Traffic on these sections averages much less than on other types, surfacing unnecessary or deferred.

(10) Bridges and trestles.—These items cover special repairs or renewals on large scale of certain structures, separately noted.

(6) In the event of a demonstrated surplus in the permanent highway maintenance fund of any county, over and above adequate provision for its prior highway maintenance obligations, such surplus is applicable only to "the maintenance or improvement of roads upon the route of primary State highways."

FIRST YEAR'S RESULTS EXCELLENT.

The law has now been in operation for more than a year and we are in a position to review and compare some of its results. The first and most outstanding fact is that the law of 1917 has provided adequate funds and fixed administrative authority and control whereby the 2,000 miles and more of constructed primary State highways, county permanent highways, and other roads of like character, are for the first time in the history of the State of Washington and its counties, being maintained on a planned, continuing system, instead of the traditional method of the "Arkansas Traveler." These main State and county roads of Washington have been maintained through one season and to the middle of a second season under a traffic averaging at least a third more than before 1917, and in many localities abnormally increased in volume and tonnage by war-time traffic development, and they are standing the test, measurably meeting even these emergency demands beyond the capacity of their construction types. Despite the combination of most expensive and difficult conditions affecting maintenance labor, materials, and transportation, and the wear upon the roads under unprecedented traffic demands, the law of 1917 has provided the funds and the organization to meet the situation. In the face of a situation which, unprovided for, would have brought break-down and destruction to hundreds of miles of our new road system, I believe it can fairly be said that the main highway system of Washington was never in better shape, under constant and substantial upkeep, than now in this midseason of 1918.

There are submitted herewith two tabular statements showing from a financial standpoint the operation of the 1917 maintenance law as applied to the constructed mileage of primary State highways for the combined year covering the period from June, 1917, to May, 1918, inclusive. The first table shows the expenditures segregated by counties, covering (1) the seven months period from June to December, 1917; (2) the five months period from January to May, 1918; and (3) the combined 12 months. The detail figures show the mileage reported on by each county, the total maintenance expenditures reported, and the average expenditure per mile in each county, for the respective periods and for the combined year. The second table shows the expenditures segregated by types of pavement or surfacing, distributed into the same two periods and for the combined year, with total expenditures, mileage, and rates per mile for each type of construction. The number of counties reporting and the number of road sections reported upon will also be found in this table, and are most necessary for basing any attempts at analytical comparisons between types.

THE MILEAGE MAINTENANCE COST.

It is interesting to note that during the seven months closing 1917 there was a total expenditure of $210,829.89 reported upon 1,243.77 miles of constructed primary highway, and during the opening five months of 1918 an additional sum of $219,358.74 upon 1,385.33 miles, or a total of $430,188.63 expended during the combined year. This does not include expenditures in a few counties on improvements under the surplus provisions of the act. It takes no account of the cost of maintaining approximately 800 to 900 miles of county permanent highways and other roads of like character not on primary highway routes, which have been maintained from the county maintenance funds under the act of 1917, but of which no reports are required to be made to State authority.

It would seem reasonable to consider that the combination of these two fractional periods will include expenditures rather more than are to be expected within a calendar year. In 1917, due to the new maintenance law not becoming effective until June 7, there was a holding off of the large spring maintenance work until after that date. In 1918, with the system under full headway, the large maintenance costs came during March, April, and May, which last year were piled up in June.

This circumstance, combined with the war-time costs of all maintenance, labor, and materials has produced the mileage average expenditure of $327.84 for the combined 12 months' period covering from June, 1917, to May, 1918, inclusive. It would seem a safe estimate that $275 per mile should cover a calendar year period, and under normal price conditions this may be brought down to $200 per mile.

There are 30 counties with sections of constructed primary State highways under maintenance, and it will be noted that the county mileage averages of expenditures vary between the abnormal extremes of $8.34 and $982.49 per mile for the year which happen to adjoin in the alphabetical list of counties, and there are all shades of variance between these extremes. These arise from unusual repairs or incidental improvements, equipment purchase apportionments, more or less resurfacing of gravel and macadam sections, all listed in these figures of maintenance and repairs and averaged over the mileage in varying degrees in the different counties. There are also expected variances between counties which must result from the varying volume of traffic and consequent wear and necessary upkeep of their sections of primary highway.

COST OF VARIOUS ROAD TYPES.

The statement of expenditures segregated by types of payment or surfacing presents an interesting field for comparative study in certain general features, even though its period is too short for any detail comparisons between pavement types. It must not be overlooked that these figures include all expenditures upon the entire highway, its roadbed, drainage, slopes, etc., as well as its surfacing or pavement. The first five classifications include what are commonly referred to as "hard-surface pavements." Recognizing that the figures for (1) brick and (5) bitulithic, etc., are largely made up of distributed costs of repairs amounting to reconstruction of short sections, and are not normal maintenance charges, it can be broadly stated that the annual upkeep cost of the approximately 150 miles of primary highway covered with hard surface pavement is from $50 to $100 per mile. In sharp contrast, the next three classifications, including the various types of oil and water-bound macadam, crushed rock and gravel surfacing, covering nearly 1,100 miles of the primary system, are costing from $250 to $350 per mile for their upkeep. Here is a distinct gap of $200 to $300 per mile of annual maintenance cost between the "hard-surface pavement" group and the "macadam-gravel" group of our primary State highways.

But plainly this contrast does not fully measure the gap, because the 150 miles of hard-surface pavements cover highway sections carrying double or treble the traffic as compared to the macadam-gravel mileage. A study of the latter by counties shows that it has varied from $75 to $900 per mile of annual maintenance cost, the variances being almost directly responsive to the traffic demands. It seems a safe conclusion that if the hard-surface pavements mileage had been of the macadam or gravel type, if it could have been maintained at all under its present traffic on such surfacing, the annual cost would have averaged more than $600 per mile. It is certain that at least $500 per mile, or the equivalent of 5 per cent interest on a $10,000 investment per mile is being saved in direct maintenance cost wherever a properly-built hard-surface pavement has replaced macadam or gravel on a heavy traffic section of highway.

THREE PUBLIC ROADS MEN GAVE LIVES IN WORLD'S STRUGGLE FOR DEMOCRACY.

The Bureau of Public Roads has three gold stars on its service flag for former members of its force who lost their lives in the Army. Two of them were killed in action in France. The third was a victim of the influenza epidemic, while in training at Camp Meade. The total number of bureau representatives in the service was 49.

Capt. Willis E. Comfort.

The first bureau man to lose his life while serving in France was Capt. Willis E. Comfort, who was killed near Soissons, July 18, last. Capt. Comfort, whose home was in Kansas and who was a graduate of the Kansas Agricultural College, class of 1914, entered the service of the bureau in June, 1915, as a student engineer in the drainage division. When the Mexican troubles broke out in the spring of 1916 he enlisted as a private in the District of Columbia National Guard and soon after went with his company to the Mexican border. Later that year he took the examination for second lieutenant in the Army, and on receiving his commission resigned from the bureau December 31, 1916.

He was a member of the first expedition sent to France in 1917, and as a lieutenant had command of a squad in the action in which the first three Americans to be killed in France fell. He was at a listening post when a German bombardment started. He was knocked unconscious by a shell bursting near him, but soon recovered and made his way back to his men. Later during the heaviest shelling he distinguished himself by making his way to a telephone station and back. He was mentioned in the reports of this action for heroic work in attempting to rescue a soldier caught under french débris, and for his conduct was promoted to captain.

At the time he was killed he was serving with Company F, Sixteenth Infantry. After being severely wounded in the fighting he refused to be evacuated to the rear, but led his company until he fell mortally wounded.

Lieut. Percy A. Rideout.

Lieut. Percy Adams Rideout, junior engineer in the Bureau of Public Roads until he left to enter the Army July 1, 1917, was killed in action on the Verdun front, France, October 8 and was buried October 10 in the officers' cemetery at Froidos, France. His own platoon formed the funeral escort and firing party. Lieut. Rideout originally enlisted as a private in the One hundred and first United States Engineers. He was a sergeant when he went overseas September 25, 1917. Later he was promoted successively to second and first lieutenant, being transferred to the First United States Gas Regiment (Thirtieth Engineers), volunteering for this dangerous and difficult service.

Lieut. Rideout was born in Ashburnham, Mass., but his boyhood was spent in Concord, that State. He graduated from the Massachusetts Institute of Tecnhology in 1911, and was for a year connected with the engineering corps of the Cleveland, Cincinnati, Chicago & St. Louis Railway. He entered the Bureau of Public Roads July 1, 1912, as engineer student, and a year later was made junior engineer. He was married: his widow, Mrs. Helen Palmer Rideout, now living in Braintree, Mass.

While with the bureau Lieut. Rideout was an efficient, trusted, and highly esteemed member of its force. The personnel of the bureau on November 8 adopted resolutions testifying to its respect for and appreciation of his character and his services, both in the bureau and in the Army.

William Brown.

Pvt. William Brown died at Camp Meade, Md., in October after an influenza attack. Mr. Brown was an Indianian and had been with the Department of Agriculture for several years. In 1917 he was transferred from the Office of Experiment Stations to the Bureau of Public Roads, and something over a year ago was made auditor of the Portland, Oreg., district office. He had registered for the draft in the District of Columbia before going there and was called for service in June, 1918. He was a member of the Eighth Company, Second Battalion, One hundred and fifty-fourth Depot Brigade.

BRIDGES MUST BE SAFE FOR MODERN HIGHWAY TRAFFIC

By J. L. HARRISON, Bureau of Public Roads.

A MARYLAND STATE HIGHWAY COMMISSION BRIDGE DESIGN.

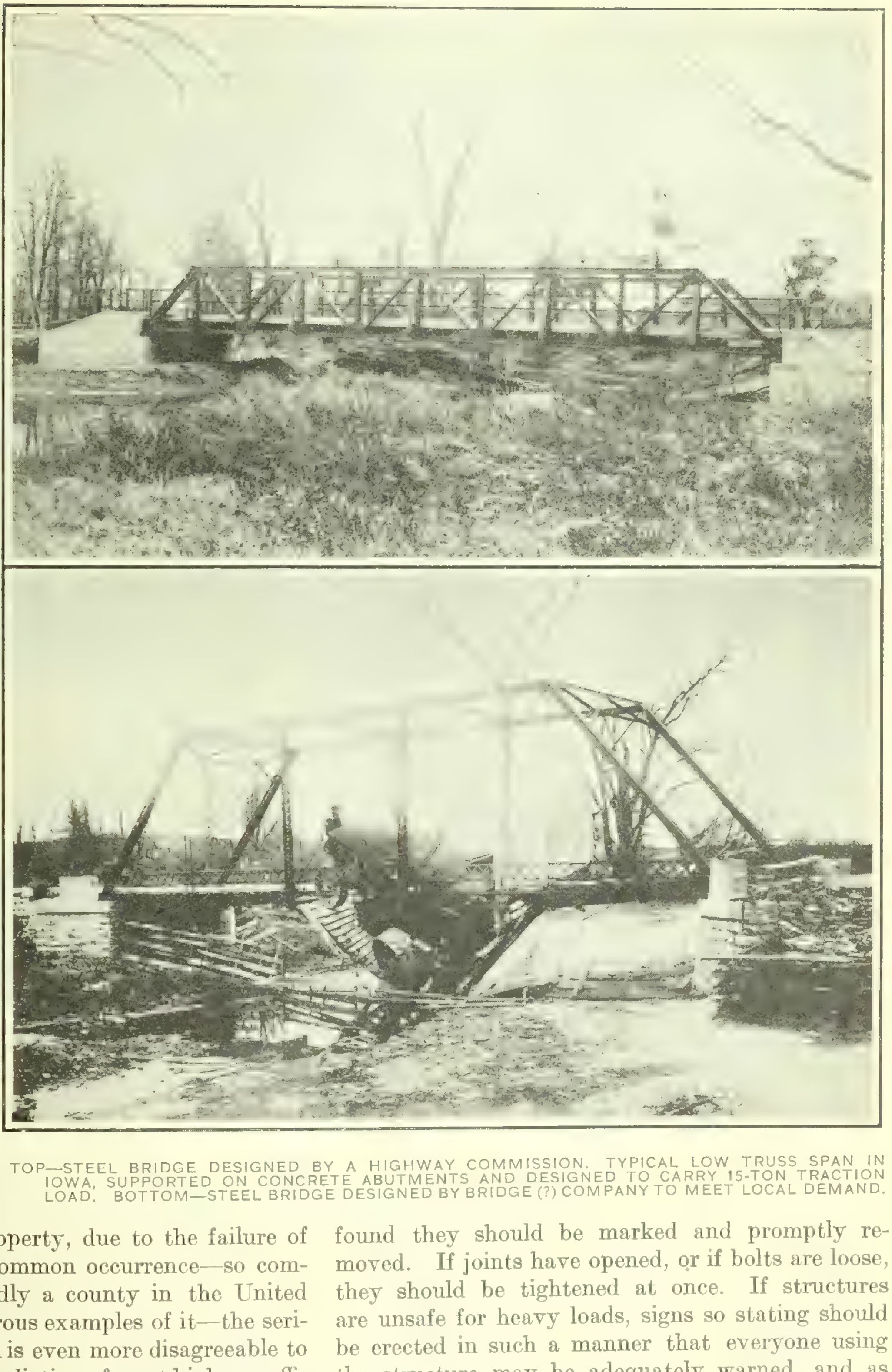
NO chain is stronger than its weakest link. Neither is any road stronger than its weakest bridge. It is, therefore, important that every highway official give careful consideration to the strength of every bridge structure which he erects, for it should be obvious that every bridge should be able to support any load which is permitted on the highway of which it is a part. Not only should it be able to support these loads when it is erected, but it should be so designed that even the heaviest loads which may come onto it will be carried without danger to the structure, and so that it may continue to perform its proper functions over a considerable period of time.

The current practice among experienced engineers is to make all highway bridges strong enough to carry the weight of the bridge itself and a load of from 12 to 15 tons at a factor of safety of from 4 to 6. In other words modern highway bridges are usually designed to carry from 50 to 75 tons of moving load. Of course no modern highway loads weigh anything like this amount, but it has been found in practice that this is advisable because of unavoidable defects in the materials used, errors and defects in construction, mistakes in design, and losses in strength due to the deterioration of the materials used, etc., all of which must be very carefully guarded against if serious accidents are to be avoided.

WHY WOODEN BRIDGES BREAK DOWN.

Wooden bridges are the source of more accidents than all other types of bridges combined. This is due to the fact that local officials who would not attempt to design a steel bridge or a concrete bridge will often turn over the design of important wooden structures to local firms of contractors and builders who, though excellent construction men, know little or nothing of the actual strength of the timber bridges which they erect. Many of these structures are strong enough to carry light loads, such as farm wagons and ordinary automobiles, but they are frequently too light for heavy trucks, traction engines, and similar heavy loads. But the traction engine and the heavy truck are legitimate and recognized traffic units and should, therefore, be provided for as carefully as the more common vehicles.

To avoid the construction of dangerous wooden bridges the proposed design should always be submitted to and approved by the State highway department or some competent bridge engineer. If this is done both the construction of bridges which are too light and the construction of those in which material is wasted will be avoided.



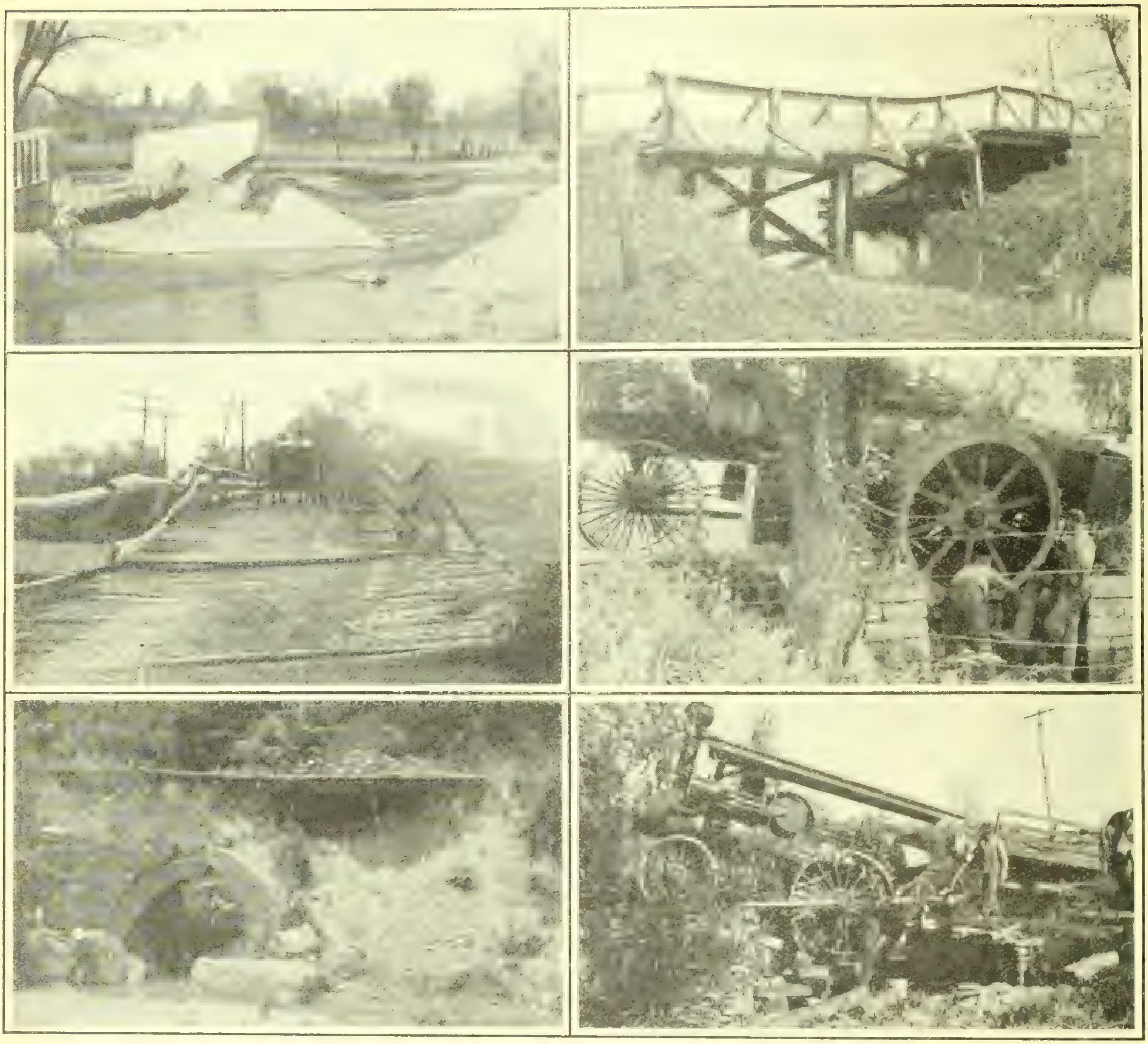
TOP—STEEL BRIDGE DESIGNED BY A HIGHWAY COMMISSION. TYPICAL LOW TRUSS SPAN IN IOWA, SUPPORTED ON CONCRETE ABUTMENTS AND DESIGNED TO CARRY 15-TON TRACTION LOAD. BOTTOM—STEEL BRIDGE DESIGNED BY BRIDGE (?) COMPANY TO MEET LOCAL DEMAND.

REGULAR INSPECTION IMPORTANT.

A still more important matter is the regular inspection of timber structures, and for that matter of all forms of bridges, to see that decay or the disintegration of the materials used has not rendered the structure dangerous. As a matter of fact, there are probably more accidents caused by the failure of responsible highway officials to inspect bridges under their care and remove rotten timbers, tighten loose joints in trusses, and otherwise keep up the structures which have been placed in their care, than can be charged to any other single cause. This is not a very creditable condition of affairs, and when it is realized that loss of life and property, due to the failure of such structures, is a common occurrence—so common, in fact, that hardly a county in the United States is without numerous examples of it—the seriousness of the situation is even more disagreeable to contemplate. The jurisdiction of most highway officials is of limited extent. Many local highway officials have only a few square miles to cover and within this area there are never many structures. Most local officials could, therefore, make a careful inspection of every structure within their jurisdiction in from one to two days. This should be done at least twice every year and it would be better to do it every three months. When decayed timbers are found they should be marked and promptly removed. If joints have opened, or if bolts are loose, they should be tightened at once. If structures are unsafe for heavy loads, signs so stating should be erected in such a manner that everyone using the structure may be adequately warned, and as soon as it is possible to do so the structure should be replaced by one which will safely carry modern heavy highway loads.

APPROVED DESIGNS NECESSARY.

Steel bridges are too often let to the lowest bidder without regard to what sort of a design he submits. As with wooden structures, plans should



TOP, LEFT—BRIDGE BUILT ON UNASSISTED LOCAL DESIGN. RIGHT—EVEN THIS COULD BE IMPROVED BY PROPER MAINTENANCE. CENTER, LEFT—UNSAFE BRIDGE WITH NO WARNING SIGN. RIGHT—HOW MUCH HAS THIS ACCIDENT COST THE OWNER OF THE TRACTOR? BOTTOM, LEFT—NO WARNING SIGN ON THIS DANGEROUS BRIDGE. RIGHT—PRIMITIVE FORM OF CONSTRUCTION CAUSES TROUBLE.

be prepared and specifications drawn before bids are asked for, and in this way the excessively light steel spans now so common in many localities will be avoided. In short, all bridge designs, steel, concrete, stone, and timber, should be prepared by competent bridge engineers. The State Highway Departments will usually give assistance in preparing these plans, or competent local engineers may be employed; but in every case bridge plans and specifications should be prepared by men who have special knowledge of this subject, and their erection should be in the hands of competent and experienced men. If this course is followed, and if then local officials will give close personal attention to the regular inspection and repair of the bridges placed in their care, the thousands of bridge accidents which now result in a large annual loss of life and property can be very largely avoided.

PROTECTION FROM SNOW.

The New York State Highway Commission will spend $20,000 in the construction of fences to keep snow from drifting into roads. The 900 towns of the State are expected to provide machines to remove snow.

INDIANA HIGHWAY BULLETIN.

The State Highway Department of Indiana has begun the publication of a monthly bulletin showing the activities of the department. The first number appeared early in October.

WORK OF THE BUREAU OF PUBLIC ROADS FOR THE LAST FISCAL YEAR.

THE Director of the Bureau of Public Roads has submitted to the Secretary of Agriculture his annual report for the fiscal year ended June 30 last. Up to that time 52, or 28 per cent, of the 187 male employees on the rolls of the bureau April 6, 1917, the date of our entrance into the war, had enlisted for military service. On September 30 the number had been increased to 72, or 38.5 per cent. In addition to these men in the military service, 18 engineers had been assigned to Army posts and cantonments to supervise and inspect highway construction. An engineer was assigned to the United States Shipping Board and one to the United States Housing Corporation of the Department of Labor to assist in working out highway and street problems in connection with housing projects.

WORK FOR MILITARY PURPOSES.

Much of the time of the engineer of tests was devoted during the year to the assistance of the Emergency Fleet Corporation in testing materials for and in the design of concrete ships. The testing laboratory was engaged to a considerable extent in the design of apparatus for the Ordnance Bureau for testing the power of explosives. Complete and detailed maps covering coast counties of a considerable part of the Atlantic seaboard region and detailed maps of the Army truck route from Detroit to Baltimore were made for Army use, the latter in cooperation with the Geological Survey and the Corps of Engineers. The principal highways in a zone extending from Boston to Newport News were plotted on topographic sheets for the use of the Geological Survey in the preparation of aeroplane maps.

Cooperation was given the Capital Issues Committee in connection with highway, irrigation, and drainage bonds. During the year inspections were made of 126 highway projects, involving bond issues aggregating $49,276,366, 25 irrigation projects involving $18,279,060, and 30 drainage projects involving $19,356,970, or a total of 181 projects involving bond issues of $86,356,396.

THE HIGHWAYS COUNCIL.

Early in 1918 an arrangement was entered into with the Fuel Administration by which that organition would issue permits for bituminous materials for highway work upon recommendation of the bureau. This work was merged in June, 1918, into the work of the United States Highway Council, which held its first meeting on June 8. It had become apparent early in the year that some method of coordinating the various powers of the Government with reference to highways was necessary, not only to the proper regulation of highway work during the war but to enable really essential highway work to be done. On request of the Secretary of Agriculture, the Secretary of War, the Director General of Railroads, the chairman of the War Industries Board and the Fuel Administrator named representatives to serve with the Director of the Bureau of Public Roads in forming the Highways Council to control highway construction in the country during the period of the war. The Director and the chief of management of the bureau serve, respectively, as chairman and secretary of the council. It has done an immense amount of work since its organization in considering highway projects submitted.

Up to June 30 under the arrangement with the Fuel Administration and under the Highways Council, 2,235 applications had been received, calling for the equivalent of 75,000,000 gallons of bituminous materials, of which 58,000,000 gallons had been approved and permits issued.

FEDERAL AID ROAD ACT.

Work under the Federal aid road act progressed well during the year. Efforts were made, in cooperation with the several State highway departments, to restrict construction work to such projects as would prove of greatest importance, serve the greatest economic or military use, and contribute to the Government's war program.

During the fiscal year legislative assent required by section 1 of the act was given by the legislatures of all the States for which such assent had not already been given except Alabama. The legislature of that State meets only quadrennially, and its next session will not be held until January, 1919, when the assent is expected. In the meantime the governor has assented for Alabama, as authorized by the act.

During the year proposed standard plans, specifications, proposal notice, contract and bond forms submitted by 34 States were reviewed. Where changes in the forms were thought desirable suggestions for the changes were made to the respective State highway departments. Proposed forms of specifications, notice to contractors, contract and bond were prepared jointly by the Bureau and the Forest Service and reviewed by the solicitor of the department, for use in connection with forest road construction. With a view to greater uniformity in the forms of specifications, notice to contractors, contract and bond used by the several State highway departments, a proposed standard form was prepared and submitted for general adoption by the States, subject to such modifications as might be necessary to adapt them to statutes and particular requirements of the respective States.

RULINGS ON AGREEMENTS.

It was determined that when a project agreement is entered into between the Secretary of Agriculture and a State highway department such agreement constitutes an expenditure of the Federal funds thereby set aside and allotted to the project; and also that a project statement might be submitted and approved and the project agreement entered into prior to the beginning of the fiscal year out of which the apportionment for which Federal payments would be made, but that construction work could not commence prior to beginning of the fiscal year.

It was also determined that any balances that may occur in connection with projects covered by project agreements will accrue to the funds available to the State for the fiscal year within which such balances occur. It was decided that it is unnecessary to specify any particular fiscal year's apportionment from which the Federal funds allotted to a project should be payable, the purpose being to consider disbursements of the Federal funds in the aggregate instead of by fiscal years.

Project statements were submitted by all the 48 States and plans, specifications and estimates by 46 States. At the end of the fiscal year construction work was in progress in 30 States, work had been completed and final payments made on 5 projects, having an aggregate mileage of 17.643, costing $347,380.70, and on which $166,274.84 Federal aid was paid. The total amount of Federal aid paid out for construction during the year was $425,445.85.

FEDERAL AID OF $16,049,821 INVOLVED.

During the year a total of 563 projects were passed upon by the department, of which 559 were approved and 4 rejected. Project agreements were entered into to cover 205 of these 559 projects and also for 13 projects approved prior to the beginning of the fiscal year. These 218 agreements involved an estimated cost of $14,239,939.15 and Federal aid of $5,658,458.42. The project statements approved and not covered by agreements involved an estimated cost of $28,038,831. 23 and $10,391,363.32 Federal aid. All the projects for which the statements were approved and into which agreements were entered have an aggregate mileage of 6,249.39, and involve Federal aid to the amount of $16,049,821.74 out of an estimated cost of $42,278,770.38.

At the beginning of the year a working plan for 1918 was prepared in cooperation with the Forest Service for the work on National forest roads. As the season advanced unfavorable conditions made it necessary to eliminate several projects until after the war. During the year preliminary investigations were made on 62 projects, reconnaissance surveys on 47 and locations surveys and plans on 41, a total of 150 projects, having a total mileage of 3,233.75. Construction was under way on about 53.5 miles of road in 10 National forests, estimated to cost $366,411.

OBJECT-LESSON ROADS.

Considerable work was done by the division of road building and maintenance investigation. Object-lesson roads were built of sand-clay construction in North Carolina, top-soil construction in Virginia and gravel construction in Texas, superintendence of the construction of county roads was conducted in Virginia, and work completed on an experimental post road in Iowa. Reports were made on county road systems for counties in Texas and California, several State highway departments were assisted in various lines of work and advice given in regard to special road problems in many States. Designs for bridges were prepared for a dozen projects in various States, and general designs and specifications whichhad been prepared by several State highway departments and local officials were examined and reviewed.

The economic highway survey, inaugurated toward the end of the preceding fiscal year, was continued. The complete maps and text give detailed information on the roads, bridges and economic conditions in the territory covered by the surveys. The work has proven of greater value than was at first anticipated, as it brings together in a workable manner much detailed highway information. It has been of value to State highway departments and to the work of the Bureau, and has proven valuable to other branches of the Government. Copies of the completed maps are supplied to the Post Office Department, Geological Survey and to the War Department.

HIGHWAY WORK IN THE STATES.

During the year a thorough investigation was completed as to the organization, personnel, powers and duties of State and local highway forces, the classification of highways, the procedure followed in their construction and maintenance, and of the method of raising and handling funds for road purposes. The results of this study are now being published.

Current data in regard to State highway mileage and expenditures and as to automobile registrations and the disposition of these revenues were collected. In the calendar year 1917 expenditures on our rural roads amounted to $279,915,332. Of this total $98,179,332, consisting of $47,290,790 State and $50,888,542 local funds, were expended under the supervision of the several State highway departments. A total of 4,983,340 motor cars, including commercial vehicles, and 257,522 motor cycles were registered in the 48 States and the District of Columbia. There was collected in registration and license fees $37,501,237, of which $23,235,898 or about 67 per cent, were expended more or less directly under the control of the State highway departments. This sum was about 49 per cent of all the State funds devoted to rural roads and bridges.

ROAD TESTS AND MATERIAL DIVISION.

The loss of employees and inability to replace them with experienced men, the cooperation with other branches of the Government in war activities and supervision of material specifications and tests for Federal aid work, and assistance to the Fuel Administration in connection with the work of the United States Highways Council cut down the research work of the Road Tests and Material Division materially, as compared with the preceding year. The work of the Conference of State Highway Testing Engineers and Chemists, held during the year 1917, was supplemented by the preparation of two bulletins. In general the recommendations of the conference were followed, with a view to standardizing specification requirements of all types of road materials.

Twelve hundred and eighty-nine samples were examined in the chemical laboratory, a decrease of 3 per cent over the preceding year. The physical laboratory tested 1,009 samples, an increase of 10 per cent, while the 630 samples of road-building materials examined and classified by the microscopic laboratory showed a decrease of 7 per cent.

As a result of research and experimental work, as well as observation of the work of highway engineers throughout the country, a set of typical specifications for bituminous materials for various types of roads and methods of use were prepared and sent to all manufacturers interested, with the request that they review the specifications and suggest changes they thought desirable, giving reasons for such changes. Upon receipt of all the information that could be secured these specifications were redrafted and published as Department Bulletin 691, "Typical Specifications for Bituminous Road Materials." This bulletin contains 30 specifications for petroleum, asphalt, and tar products, with descriptions of the general methods of use for which the materials are suitable, methods of testing the materials for conformity with the specifications and directions for sampling. An investigation of the relation of the consistency of road oils at normal temperature to the so-called asphalt content test has been completed.

QUARRY INVESTIGATIONS.

During the year an exhaustive investigation of commercial quarry practice in the production of crushed stone for road-building purposes was begun. A special study was made of such practices in the New England and Middle Atlantic States. A progress report, "The Commercial Sizes of Broken Stone Aggregate," has been published, and a report has also been prepared on small scale production, dealing in an elementary manner with the selection of quarry sites and the installation and operation of equipment. The survey of quarry conditions in the United States has been continued in the West and South, and so so far about 170 quarries have been studied.

Subjects under investigation at the end of the year included the suitability of various types of soil for the construction of bituminous soil roads, the standardization of screening practice in the production of crushed stone, and the use of slag in road construction.

Cooperative work with the American Society for Testing Materials was continued, and as a result a number of standard methods and definitions were recommended to the society for adoption.

ROADS AS MEMORIALS.

A suggestion is advanced in the Minneapolis Tribune as to memorials for those who sacrificed their lives for liberty. The idea is that there are better things with which to memoralize the dead than stone monuments and mausoleums, and particularly appropriate would be works of public utility in memory of those who lost their lives in the war and whose bodies received burial on the field of battle. The suggestion is that the money which would be expended on shafts and statues be used for road building, the road to bear the name and probably some other means of identification, so as to constitute a memorial to the dead.

PRISON LABOR IN NEW JERSEY.

The New Jersey State Highway Commission has made an arrangement with the department of corrections and charities for the use of inmates of the reformatory at Rahway by the contractor of section 1 of State Highway route No. 1 in Metuchen. The contractor was unable to secure sufficient labor to complete the pavement before cold weather set in, and this reformatory labor was resorted to in in the emergency. Commissioner Clark states that this labor is proving both economical and highly efficient. It is thought that more and more labor of this sort will be used in the State under similar conditions.

STRETCH OF BRICK ROAD IMPORTANT NEBRASKA FEDERAL AID PROJECT

By E. H. MOREY, Assistant State Engineer.

DURING the past three months (August–October) Nebraska has had 200 miles of Federal aid roads under contract. The most important of these is a stretch of 5½ miles, 3-inch vertical fiber brick pavement on a 5-inch concrete base, constructed between Lincoln and Emerald, in Lancaster County. This road embodying the essential qualities necessary for modern commercial transportation will receive at its completion a large share of interstate traffic, as it is a portion of the O. L. D. Highway on the direct route from Omaha, Nebr., to Denver, Colo.

The original earth road consisted of humus and clay. In about two-thirds of the mileage the road was of a clay base with a light surface of humus. The remaining one-third was of pure clay. Drainage was very poor. The road situated as it was in the center of an agricultural district proved worthless for traffic in certain seasons of the year. During the heavy spring and fall rains, the clay hills, being of a gumbo quality, worked up easily and as a result deep chuckholes and ruts were so frequent that it was finally decided nothing short of hard surfacing could withstand the traffic.

Accordingly contract for plans was undertaken by the county through Federal aid, under direction of the State board of irrigation, highways, and drainage. The construction company awarded the contract began work April 24 with about 80 laborers. There was one woman on the job who drove a team.

The line of the Lincoln-Emerald road runs on a section line and is comparatively straight. The problem of drainage made a complete drainage survey necessary.

GIVEN WELL-DRAINED FOUNDATION.

The original road furnished excellent data; and careful consideration on the part of the engineer in charge has resulted in a well-drained foundation.

The road is 22 feet wide for the first mile where it adjoins Lincoln, and 18 feet wide the remainder of the 5½ miles. It has 10-foot earth shoulders, 2-foot ditches made with a 1-to-1 slope. The crown is 4 inches. Concrete for the base is prepared in a three-fourths yard steam propelled mixer, with a carrier discharge. Specifications called for a 1–3–5 mixture. Considerable difficulty was experienced in the setting of the concrete on the second mile of roadway. However, this was caused by a period of dry weather and hot winds. A heavy rain set the concrete in first-class condition, and it was ready for the sand cushion. The sand was loaded from a local sand pit and hauled a distance of 2 miles to the work, where it was spread to a thickness of 2 inches.

One of the labor-saving devices used was the brick carrier. It consists of a long trough with wooden rollers on which the bricks were carried from the pile to the layer. It required two men to load the bricks and one to lay them. An average of 33 bricks to the yard and approximately 700 yards were laid per day. About 50 carloads of brick laid 1 mile. The vertical fiber bricks were freighted from Galesburg, Ill.

A filler of asphalt and residium oil was applied after the bricks had been carefully rolled, and sand sprinkled over it.

THE LABOR SITUATION NOT SERIOUS.

The labor question is not as yet serious in the road construction problem in Nebraska. Three and one-half to four and one-half dollars per day is paid to the ordinary workman. This work is inspected by representatives from the Frederal Government, State and county. The State appropriated $35,000 and the Federal Government $35,000, the remainder being paid by the abutting property owners.

The construction now is 75 per cent finished. When complete, 5½ miles of one of the best roads in the State of Nebraska will be opened to all kinds of traffic. A military training school is within 1 mile of the new road. Dairy and poultry, as well as agricultural farms, adjoin the entire route. With the establishment of the "Return Load Bureau," this portion of the roadway will afford a "marketing highway" of vast importance.

The subject of good roads has stimulated widespread interest in every county throughout the entire State. Nebraska farmers especially are pushing the improvement of present roads with feverish haste. Nebraska people are awakening to the possibilities of what good roads mean, and are unwilling to be outdone in this movement by any other State in the Union.

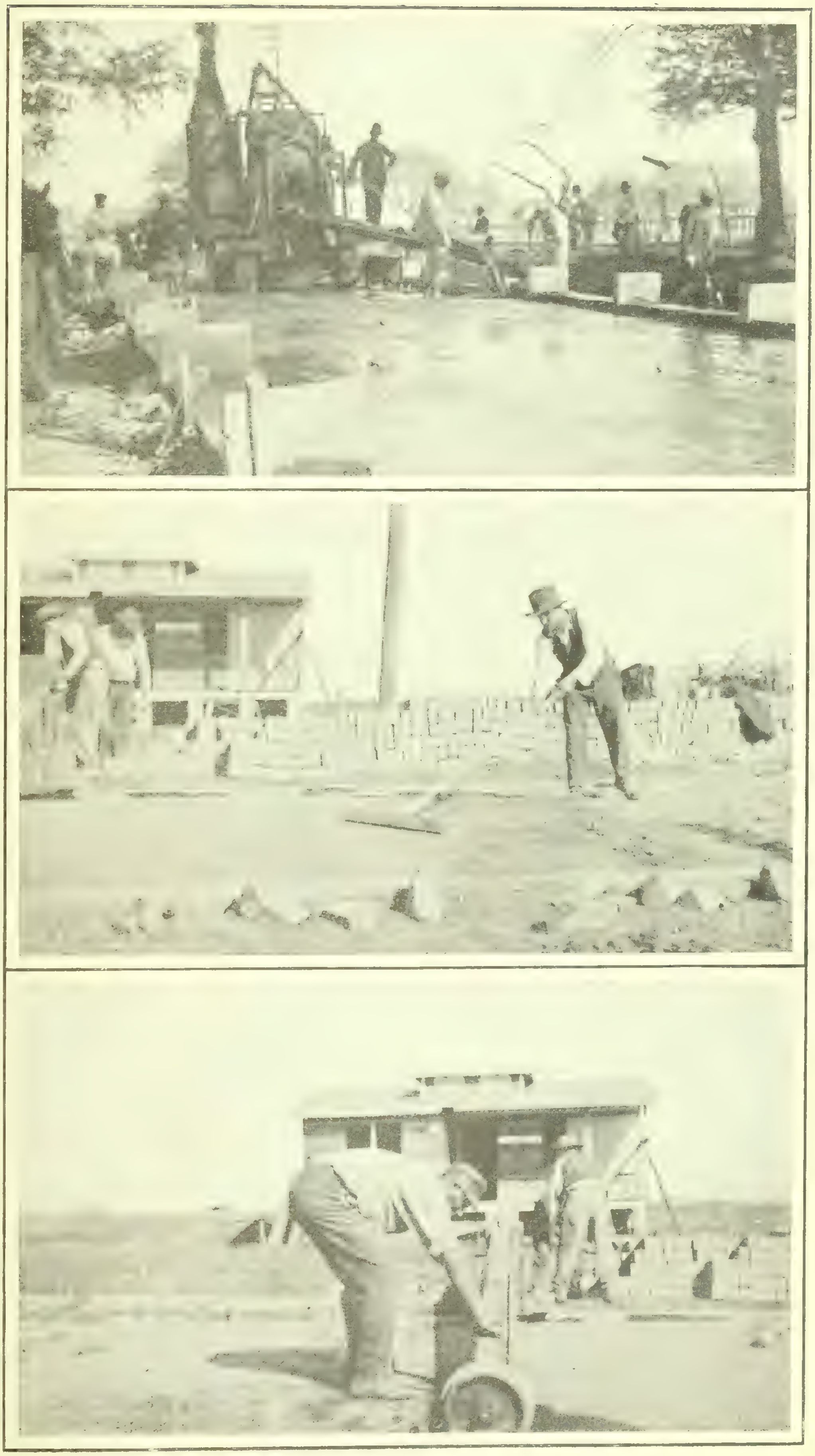
AUGUST AND SEPTEMBER FEDERAL AID.

In August the number of Federal aid projects which went to final agreement exceeded those approved, the numbers being 46 and 30, a total of 76 projects on which action was taken. The total cost of these 76 projects is estimated to be $6,391,269.47 and the Federal aid allowance $2,326,683.61. The aggregate road mileage of all projects is 733.965. Twenty bridges are included in the projects.

Georgia led in the number of projects considered. Nine in that State were approved and three others went to final agreement. The former, including 17 bridges and aggregating 63.1 miles of sand-clay, top-soil, and other roads, are estimated to cost $413,811, with an allowance of $180,658.96, and the latter for 26.29 miles of road and one bridge will cost $217,656.18, with an allowance of $100,000. The total estimated cost of the Georgia projects is $631,469.18 and the Federal aid $280,658.96.

Texas and Michigan each had 6 projects considered. One Texas project, for 3.275 miles of bituminous gravel road, was approved, and final agreements were signed for five, with an aggregate mileage of 58.769, estimated to cost $308,357.63 and an allowance of $142,077.70. Final agreements were signed for all the six Michigan projects. They involved 2.884 miles of brick or concrete and 27.513 miles of gravel road, at an estimated cost of $453,829.40, with Federal allowance to the amount of $203,816.19.

The largest expenditures proposed are for two Kansas roads,



CONSTRUCTION OF A FEDERAL AID BRICK ROAD IN NEBRASKA. TOP—LAYING CONCRETE BASE. CENTER—SPREADING SAND CUSHION. BOTTOM—LAYING THE BRICK.

39.70 miles of concrete, estimated to cost $1,172,797.53. Final agreements were signed for both projects, with an allowance of $175,919.64. The largest allowance during the month to a single State was $284,040 for two Maine roads, aggregating 28.45 miles of bituminous macadam, and which are estimated to cost $667,171.20. Two Ohio projects, one 11.92 miles of brick or concrete the other 7.45 miles of brick, are estimated to cost $580,700. The allowance made in the agreements is $146,119.50.

Minnesota led in the total mileage of projects. Four from that State for gravel roads, for which final agreements were signed, aggregated 104.62 miles. The estimated cost is $321,676.81 and the Federal allowance $105,000.

In September 39 Federal aid projects were approved and final agreement for 9 were signed. The mileage of all the projects was 427.939 and the estimated cost $3,906,672.65, while the allowance amounts to $1,383,481.44.

Maryland projects involve the greatest cost and will receive the largest Federal aid allowance. Two concrete roads in that State aggregating 70 miles are estimated to cost $720,000, with an allowance of $360,000.

Final agreement executed for a single project in Delaware was for 5.72 miles of brick road, estimated to cost $639,349. Only $5,000 a mile Federal aid was requested and allowed for the project, the total allowance being $28,550.

A single project in Ohio approved is for 8.09 miles of brick road to cost $390,000, for which the allowance is $80,000. Georgia led in the number of projects considered in September as in August. The 6 projects approved and the one for which final agreement was signed aggregate 42.44 miles, estimated to cost $332,324.29, with an allowance of $140,591.04. Alabama had 5 projects approved, for 24.056 miles of gravel and sand-clay roads.

FEDERAL AID PROJECTS IN AUGUST, 1918.

State.	Project No.	County.	Length in miles.	Type of construction	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	32	Conecuh	6.01	Sand-clay	Aug. 6		$36,001.95	$18,000.97
	34	Montgomery	.24	Bridge	...do....		49,225.00	17,000.00
Arizona..	6	Apache	13.00	Gravel	Aug. 10		130,020.00	65,010.00
Georgia..	4	Oconee and Walton	10.782	Topsoil		Aug. 26	50,269.44	20,000.00
	5	Alma, Nichols, Bacon	17.71	Sand-clay		..do.	46,411.33	20,000.00
	7	Macon	0.89	Sand-clay, 2 bridges		Aug. 13	120,975.41	60,000.00
	8	Montgomery and Wheeler	0.60	Bridge	Aug. 28		90,008.87	42,500.00
	9	Rabun	8.00	Graded and drained earth	...do....		46,728.00	20,000.00
	10	Towns	9.00	..do	...do....		44,027.50	16,158.96
	15	Coweta	4.00	Topsoil or sand-clay	...do....		18,843.00	7,000.00
	16	Meriwether	12.40	....do	...do....		42,053.00	14,000.00
	17	Harris	19.00	Earth surfaced with topsoil in part.	...do....		42,944.00	21,000.00
	26	Bulloch		7 bridges	Aug. 13		43,246.50	20,000.00
	29	Emanuel		8 bridges	...do....		54,961.50	25,000.00
	36	Douglas	12.10	Topsoil	Aug. 28		31,047.50	15,000.00
Illinois..	[illegible]	Marshall	21.60	Concrete and earth	Aug. 21		280,680.00	90,000.00
Iowa..	21	Jackson	16.50	Earth	Aug. 6		60,280.00	25,090.00
Kansas	13	Leavenworth	22.00	Concrete	Aug. 21		548,963.51	82,344.54
	15	Reno	17.70		Aug. 26		623,834.02	93,575.10
Maine..	1	Brunswick	15.57	Bituminous macadam		Aug. 14	337,789.31	155,700.00
	3	Kennebec	12.88	....do		Aug. 26	329,381.91	128,340.00
Michigan	9	Washtenaw	2.881	Concrete or bricks		Aug. 28	86,708.99	28,840.00
	10	Arenac	6.883	Gravel		Aug. 13	88,170.49	44,085.24
	11	Alpena	5.525	...do.		Aug. 1	48,265.69	24,132.84
	13	Livingston	6.52	....do		Aug. 13	104,939.25	43,885.62
	14	Barry	4.333	...do.		..do....	84,659.44	42,329.72
	15	Livingston	4.232	...do.		..do....	41,085.54	20,542.77
Minnesota	14	Carver	26.49	...do.		...do....	50,146.66	20,000.00
	20	Goodhue	21.25	..do.		Aug. 28	133,486.34	35,000.00
	32	Lyon	27.78	....do		..do....	58,545.43	25,000.00
	35	Murray	29.10	...do...		...do....	79,498.38	25,000.00
Mississippi	33	Tunica	4.03	Clay gravel	Aug. 10		25,245.00	12,500.00
	34	Madison	6.00	Gravel	Aug. 6		28,792.00	14,000.00
Missouri...	8	Harrison	9.60	Concrete and macadam	Aug. 28		141,669.00	70,834.50
	11	Callaway	7.60	Gravel	Aug. 14		42,759.64	21,379.82
	12	Cole and Osage		Bridge	Aug. 2		105,050.00	52,525.00
Nebraska	17	Lancaster	9.99	Graded earth		Aug. 26	40,155.00	20,077.50
	19	.....do	4.00	Earth	Aug. 22		15,840.00	7,920.00
Nevada....	2	Nye	14.75	Gravel		Aug. 30	44,120.45	22,060.22
New Hampshire.	14	Coos	0.95	Bituminous macadam		Aug. 13	15,052.24	7,526.12
North Carolina...	4	Craven	9.46	Topsoil and sand-clay		Aug. 28	21,089.23	10,000.00
	9	Polk	13.02	Gravel	Aug. 13		30,717.35	14,000.00
	31	Buncombe	2.60	Concrete	..do....		77,442.20	20,000.00
North Dakota.	1	Cass	16.33	Graded earth		Aug. 16	15,015.13	7,527.56
	2	Foster	15.00	Gravel and earth		Aug. 13	16,257.32	8,128.66
	7	Stutsman	9.20	Earth		Aug. 29	19,424.98	9,712.49
	14	Stark	18.90	.....do		Aug. 12	29,720.22	14,860.11
	20	Wells	16.80	Graded earth		Aug. 13	22,512.73	11,256.36
	21	Bowman	17.70	.....do		Aug. 12	23,584.38	11,792.19
	28	Ransom	25.50	Earth	Aug. 28		41,272.00	20,636.00
	32	Cass		2 bridges	Aug. 22		19,954.00	9,977.00
Ohio	11	Ashtabula	11.92	Brick or concrete		Aug. 26	141,000.00	119,000.00
	18	Highland	7.43	Brick		..do....	139,700.00	27,119.50
Oklahoma..	3	Oklahoma	2.04	Brick, concrete, asphalt or pitch		Aug. 16	46,172.80	20,400.00
	4	Comanche	2.70	Concrete		Aug. 2	53,600.00	26,800.00
	5	Bryan	11.64	.....do		Aug. 29	223,679.59	111,839.79
Oregon.	5	Union	9.55	Earth		Aug. 22	41,151.00	20,575.50
	8	.....do.	6.01	.....do		...do....	30,000.00	15,000.00
	11	Baker	4.15	Graded and drained earth.	Aug. 7		22,498.00	11,249.00
South Carolina	1	Richland	2.12	Concrete		Aug. 1	51,679.11	24,352.60
Tennessee.	5	Greene	2.64	Water-bound macadam	Aug. 6		38,321.91	19,160.95

FEDERAL AID PROJECTS IN AUGUST, 1918—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Texas	2	Brooks	20.10	Sand-clay or gravel		Aug. 26	$11,725.52	$20,000.00
	21	Gregg	11.49	Bituminous macadam		do	57,970.97	19,000.00
	31	Bexar	18.182	Bituminous gravel		Aug. 30	110,168.74	55,084.37
	33	Harris	4.157	Gravel shell base, bituminous surface		...do...	33,309.36	15,397.81
	49	Nolan	11.84	Sand, clay, and gravel		Aug. 29	65,191.04	32,595.52
	73	Gaudalupe	3.275	Bituminous gravel	Aug. 21		12,156.68	5,000.00
Virginia	9	Chesterfield	3.07	Concrete		Aug. 13	69,017.39	30,600.00
	11	Lee	2.16	Waterbound Macadam		Aug. 12	42,100.00	21,050.00
	16	Botetourt and Rockbridge	5.398	...do..	Aug. 6		49,384.28	24,692.14
Washington	12	Thurston	3.526	Concrete		Aug. 14	87,964.50	35,000.00
West Virginia	14	Mingo	4.00	Earth		Aug. 13	54,700.00	8,075.00
	19	Ohio	.568	Concrete		Aug. 14	11,435.25	5,680.00
Wisconsin	4	Shawano	7.31	Gravel		Aug. 26	35,710.59	11,903.53
	9	Kewaunee	1.50	Gravel macadam		...do...	8,994.48	2,998.16
	34	Iowa	8.17	Earth		..do...	20,569.95	6,856.65
	37	Portage	5.98	Gravel		do...	23,897.48	7,965.83
Total			733.965				6,391,269.17	2,328,683.61

Revised agreement, original executed August 27, 1917.

RECORD OF FEDERAL AID PROJECTS IN SEPTEMBER, 1918.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	31	Lamar	6.14	Gravel	Sept. 28		$21,240.50	$10,620.25
	33	Dale	2.72	Sand-clay	...do...		16,093.00	8,046.50
	35	Pike	6.00	.....do	Sept. 9		15,587.00	7,793.50
	36	Covington	2.00	.....do	...do...		15,807.00	7,903.50
	37	Jackson	7.196		...do...		33,964.92	16,982.46
Arkansas	20	Poinsett	8.84	Gravel	Sept. 12		61,029.10	30,000.00
Delaware	1	Newcastle	5.72	Brick		Sept. 12	639,349.59	28,550.00
Florida	6		5.59	Sand-clay	Sept. 18		20,228.84	10,114.00
Georgia	3	Brooks and Lowndes	6.64	.....do		Sept. 5	61,965.39	30,000.00
	19	Bleckley	7.80	Earth	Sept. 18		30,008.00	15,000.00
	28	Paulding	9.15	Sand-clay or gravel	Sept. 9		30,767.00	15,000.00
	33	Troup	5.95	Sand-clay	Sept. 28		44,434.52	20,000.00
	34	Haralson	7.40	Topsoil	Sept. 19		30,371.00	15,000.00
	37	De Kalb	5.50	Concrete	Sept. 18		134,778.38	45,591.04
Iowa	13	Webster	12.00	Gravel	Sept. 9		56,466.17	28,233.08
	22	Linn	17.80	Brick, concrete, gravel, and earth	Sept. 28		129,712.00	27,718.86
Kentucky	8	Boyd	5.34	Bituminous macadam	Sept. 9		110,000.00	55,000.00
Maryland	6	Prince George, Howard, and Baltimore.	25.00	Concrete	Sept. 19		[1] 350,000.00	175,000.00
	7	Baltimore and Hubbard	45.00	.....do	...do...		370,000.00	185,000.00
Massachusetts	9	Essex	3.122	Bituminous macadam	Sept. 18		125,224.55	31,220.00
Michigan	24	Berrien	7.916	Macadam surface treated	...do...		167,375.24	72,090.16
Missouri	4	Boone	2.79	Bituminous macadam		Sept. 9	32,281.97	16,140.98
	13	Buchanan	2.20	Asphaltic	Sept. 28		42,802.32	21,401.16
Montana	15	Rosebud	4.00	Gravel	Sept. 12		16,414.20	8,207.20
	16	.....do	4.00	.....do	...do...		14,251.38	7,125.69
Nevada	1	Humboldt	16.70	.....do		Sept. 24	77,952.16	38,976.08
	7	Washoe	9.32	Gravel or macadam		Sept. 12	57,983.20	28,991.60
New Hampshire	19	Cheshire	.60	Gravel	Sept. 9		9,037.08	4,518.54
North Carolina	24	Wake	4.24	Concrete	Sept. 12		68,606.45	25,000.00
	26	Davidson	12.88	Topsoil or sand clay	Sept. 17		22,517.00	10,000.00
	30	Mecklenberg	6.324	Concrete and bituminous macadam	Sept. 18		102,551.00	26,900.00
North Dakota	4	Richland	20.00	Earth		Sept. 12	19,198.65	9,599.32
	15	Sargent	31.50	.....do	Sept. 9		48,992.79	24,496.39
	30	Divide	9.50	.....do	Sept. 12		10,648.00	5,324.00
Ohio	23	Stark	8.09	Brick	...do...		390,000.00	80,000.00
Oregon	14	Grant	2.20	Gravel	Sept. 30		51,435.25	22,000.00
South Carolina	18	Greenwood	7.29	Topsoil	Sept. 18		18,649.95	9,324.97
	20	Cherokee	9.26	...do	Sept. 13		39,561.50	16,802.99
South Dakota	8	Butte	11.50	Earth	Sept. 9		20,638.20	10,319.10
Texas	10	Williamson	21.50	Bituminous gravel		Sept. 9	100,095.17	50,000.00
	25	Dallas	3.00	Macadam with asphalt surface		Sept. 12	25,155.87	10,000.00
Virginia	10	James City and York	2.462	Concrete	Sept. 18		69,014.44	24,620.00
	14	Augusta	4.012	Waterbound macadam	Sept. 20		49,609.44	24,804.67
	17	Hanover and Caroline		Bridge	Sept. 13		17,392.65	8,696.32
	18	King and Queen, Gloucester, and Middlesex.	13.777	Gravel and drained	...do...		39,660.81	19,830.40
	19	Fauquier	5.04	Macadam	Sept. 18		57,609.35	28,804.68
Wisconsin	13	Clark	8.81	Graded earth	Sept. 9		20,229.00	6,743.00
Wyoming	12	Lincoln	4.12	Gravel		Sept. 26	19,982.62	9,991.00
Total			427.939				3,906,672.65	1,383,181.44

[1] Conditionally approved July 17.

SEEKS RELIEF FROM ROAD COST.

Mariposa County, Cal., is seeking relief from interest charges on bonds issued for the building of the State highway in that county. Officials of the country say that the State has spent $340,000 in building a 23-mile road in the county which is traversed mainly by Yosemite tourists, and therefore serves the outside public more than residents. The interest on the bonds for which the county is charged is $17,336.56, which means a levy of 50 cents per $100 valuation, and this, it is maintained, will be an unjust burden. The law provides that interest on State highway bonds must be paid by the county in which the road is built, but a clause permits relief in cases where such taxation is an unreasonable burden to the county.

STATE HIGHWAY MANAGEMENT, CONTROL, AND PROCEDURE

By M. O. ELDRIDGE, Assistant in Road Economics, G. G. CLARK and A. L. LUEDKE, Engineer Economists of the Bureau of Public Roads.

IN the August and September numbers appeared the chapters on State highway management, control, and procedure. In this number are presented the chapters on two additional States. Each one takes up the development and results of State participation and control of road work and the relation of State to local control; organization, personnel, duties and powers of State and local road officials; classification of State and local roads with particular reference to control and basis of payment, including methods of selection, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by the State and local officials over road construction and maintenance; sources of State and local funds, basis of allotment and apportionment of State funds, and the relation of State to local funds, and the amount available for road purposes during the latest calendar or fiscal year.

MARYLAND.

Development.—Maryland was among the first States to adopt the principle of State participation in road building. By long-continued and systematic effort and by gradual development there has been constructed a system of about 1,350 miles of first-class trunk-line highways traversing the entire State east and west, north and south. These roads have been constructed and are being maintained at the expense of the State and are entirely under State jurisdiction, both for construction and maintenance. In addition to this, 375 miles of State-aid roads have been constructed at the joint expense of the State and counties. At present these roads are maintained by and at the expense of the State. There are approximately 16,460 miles of public road in Maryland, of which about 2,900 miles, or 17.6 per cent, have been surfaced. Thus about 10.5 per cent of the entire mileage is under State jurisdiction both for construction and maintenance, leaving 7.1 per cent of surfaced roads over which the State has no control.

In 1898 the general assembly authorized the Maryland geological and economic survey to correct and disseminate information on road building, and appropriated $10,000 per annum for the purpose. This appropriation for educational and propaganda work was continued until 1904, when the State-aid law was adopted. The geological and economic survey continued to handle the work until 1908, when the State road commission was created and a State road system was provided for. The general assembly of 1908 provided for an issue of $5,000,000 worth of bonds with which to construct State roads. In 1910 enlarged powers were given to the State roads commission and additional bonds for State roads were provided for.

The State funds available for construction and maintenance of State roads and State-aid roads amounted to $2,138,000 during 1917. The local expenditures not under State control, including county contributions with State aid, amounted to about $3,300,000, thus showing that the State contributes approximately 39 per cent of all road expenditures. From 1898 to 1917, inclusive, the State expended approximately $22,000,000 for the construction and maintenance of State and State-aid roads. During 1917 the total expenditure from all sources amounted to $6,083,682.

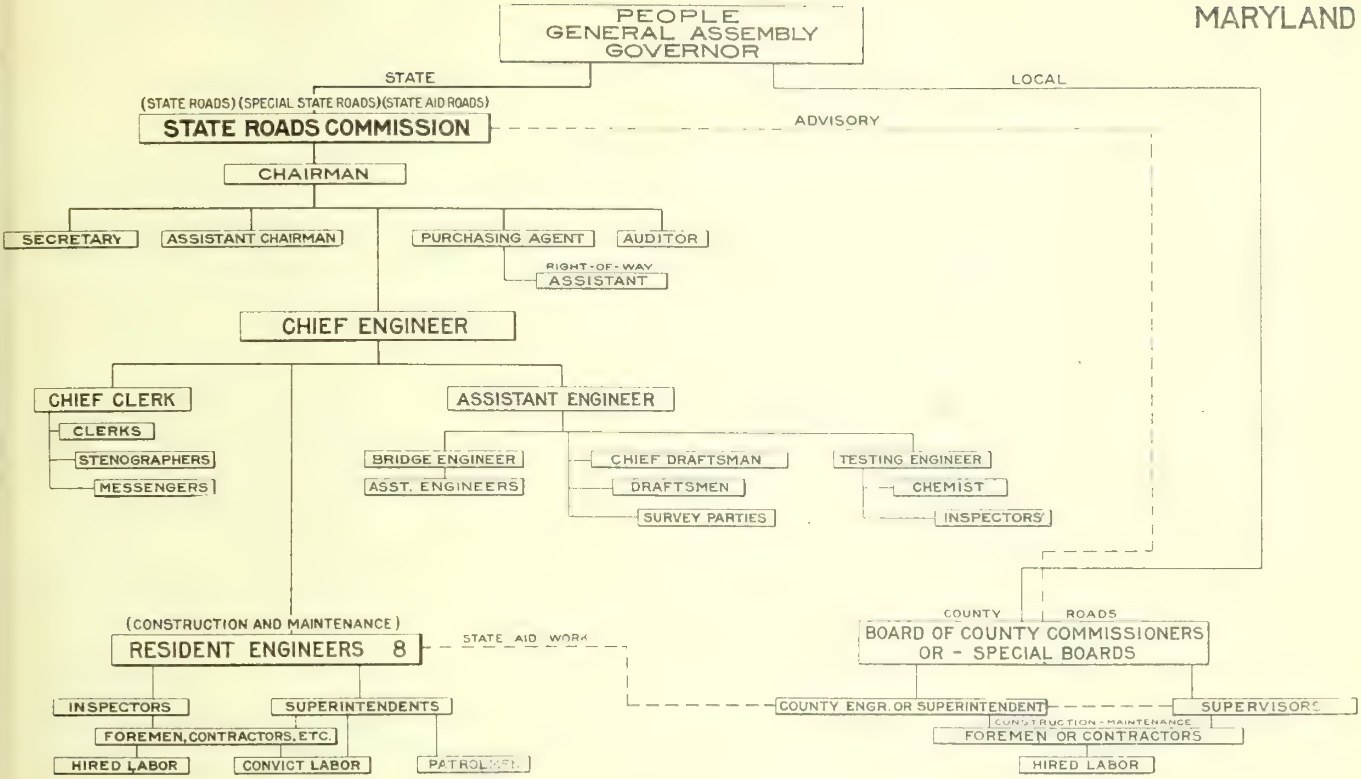
ORGANIZATION.

The highway organization of the State and the relation existing between the State and local forces is shown in the diagram given herewith.

State.—At the head of the State highway department is the State roads commission, consisting of three salaried members appointed by the governor and the governor ex-officio. The members may be removed by the governor at any time. They receive a salary of $2,000 each except the chairman designated by the governor, who receives $2,500 per annum. The commissioners must be residents of the State and at least one of them must belong and be affiliated with "that one of the two leading political parties of the State opposite to the governor's own political party."

All engineering and technical work of the department is under the chief engineer, who is appointed by the commission and serves during its pleasure. All clerical and technical employees of the department except the secretary are appointed by the commission and serve during the pleasure of the commission under the chief engineer. There is an assistant engineer who has charge of field parties, drafting, testing, and bridge work under the chief engineer. There are also eight division engineers who have charge of construction and maintenance

MARYLAND



in the field and to whom all field inspectors having immediate charge of construction and all superintendents having direct charge of maintenance report. The division engineers report to the chief engineer. The clerical work of the department is handled by a chief clerk who reports to the chief engineer. The commission also has a secretary, a purchasing agent, and an auditor, all of whom report directly to the chairman of the commission. The secretary's position is statutory.

Local Organization.—Jurisdiction over all county road and bridge matters is vested in the respective boards of county commissioners, who are elected biennially. The number of commissioners varies in the different counties, being fixed by the code of local laws for each county. In a few of the counties control over road and bridge work is vested in special appointive bodies known as good roads commissions, road boards, road commissioners, etc. All subordinate road officials are appointed by the county commissioners, who are authorized to employ district supervisors in some counties, while in others the work is carried on under the immediate direction of county road engineers or county superintendents. Several counties in the State operate under special laws.

CLASSIFICATION, CONTROL, AND PROCEDURE.

Public roads of Maryland are, for the purpose of fixing responsibility for construction, control, and maintenance, divided into three main groups, namely, State roads, State-aid roads, and county roads.

State Roads.—The State roads commission has absolute control over the construction and maintenance of State roads. At present the system includes 1,300 miles of completed trunk-line roads, and 53 miles of special roads (the Baltimore and Annapolis and the Baltimore-Washington boulevards).

The State roads are selected by the State roads commission after public hearings and the special roads are designated by the general assembly, but the exact location is fixed by the State roads commission. The State pays the entire cost of construction and maintenance. The patrol and gang systems of maintenance are extensively used in the maintenance of State roads. State convicts may be used by the State roads commission for construction and maintenance, and if so used the State pays from State funds for the maintenance of such convicts.

State-Aid Roads.—These are constructed at the joint expense of the State and counties and under the general supervision of the State roads commission. On January 1, 1918, about 375 miles of State-aid roads had been completed. Petitions for State aid originate with county commissioners or with two-thirds of the property owners abutting on the road, who agree to pay 10 per cent of the cost. County commissioners forward petitions to the State roads commission, who may grant aid or reject petition. Surveys, plans, specifications, and estimates are made by the State roads department, but the county is required to pay $50 per mile for making surveys. After plans, specifications, and estimates are approved by the State roads commission and the county commissioners the latter advertise for bids and let the contract subject to the approval of the State roads commission. The work then proceeds under the direction of a resident engineer of the State highway department, the expense of supervision being apportioned to the various State-aid projects. Payments for construction are made on monthly estimates, 50 per cent by the State and 50 per cent by the counties. Of the counties' share, 10 per cent is charged to abutting property owners.

State convicts may be used by the State roads commission, and, if so used, the State-aid money apportioned to any county may be used by the county commissioners to pay for the maintenance of such convicts.

Previous to 1916 State-aid roads were maintained by and at the expense of the counties under State supervision, but the law of 1916 provided that such roads should be maintained by and at the expense of the State in the same manner as State roads. All State-aid roads constructed previous to 1916, which were first put in good condition by the counties, were taken over by the State. The State roads commission allows $250 per mile for maintenance on all such roads which have not been so taken over.

County Roads are those constructed and maintained by the county with county funds and include all roads in the State except those above indicated. There are about 14,735 miles of county roads in the State, of which about 1,175 miles had been surfaced up to January 1, 1917. County roads are built by contract, day labor, or with county or State prisoners. If State convicts are used, the county benefited pays for their maintenance.

REVENUES.

State. Funds for the construction of State roads and special State roads are derived from State bond issues. Funds for the construction of State-aid roads are derived from State appropriations, while funds for the maintenance of State and State-aid roads are derived from net automobile fees funds collected by the State automobile commissioner. Four-fifths of the automobile fees funds are used for State purposes and one-fifth is apportioned to Baltimore City for the maintenance of roads and streets in the city. Funds used for administration and engineering are taken as needed by the State roads commission from the various appropriations and funds available. The State road funds are expended at the discretion of the State roads commission, except on special roads for which specific sums are set aside by the general assembly. State-aid appropriations are apportioned to the various counties on a mileage basis, while the motor vehicle funds are apportioned by the commission to the various counties as needed. From 1908 to 1916 $200,000 annually was appropriated by the general assembly for State-aid roads. Since 1916 the annual appropriation has amounted to $300,000. Thus, the State has appropriated and applied to construction of State-aid roads from 1908 to 1917, inclusive, approximately $2,300,000.

The State funds available for all State and State-aid purposes during the fiscal year 1917 were as follows:

Construction of State roads, fiscal year ending September 30, 1917	$1,200,000
Construction of State-aid roads, fiscal year ending September 30, 1917	300,000
For maintenance of State and State-aid and special roads from automobile fees fund, May 1, 1917 to April 30, 1918	628,000
Total State funds	$2,128,000

Local.—Funds for the construction of county roads are derived from regular and special levies fixed by the boards of county commissioners, and from county bond issues authorized by the general assembly. The sums raised, including county contributions, to meet State-aid amounts to approximately $3,300,000 annually.

BONDS.

State.—The State constitution provides that no public debt may be contracted by the general assembly unless an annual tax is provided which will be sufficient to pay interest and retire the debt as it falls due, and that the principal of such debts shall be paid within 15 years. The terms of State bonds are, therefore, limited to 15 years and the law authorizing the debts fixes a State tax sufficient to pay interest and principal. The total amount of State road bonds authorized by the five general assemblies 1908, 1910, 1912, 1914, and 1916 was $18,930,000, and are given in detail as follows:

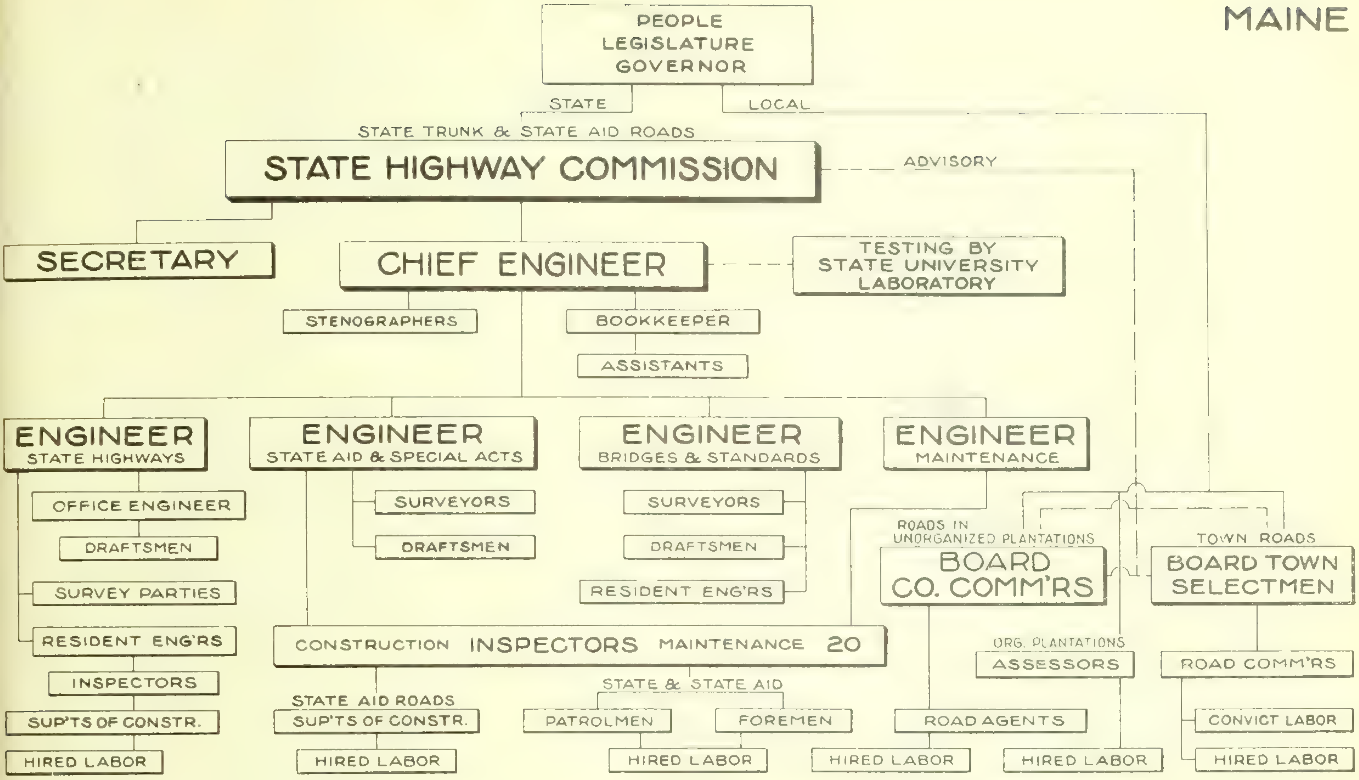
Year authorized	Amount authorized.	Interest rate.	Net proceeds.
		Per cent.	
1908	$5,000,000	3½	$4,760,209.76
1910	1,000,000	4	991,447.55
1912	3,170,000	4	3,110,432.61
1914	6,600,000	4	6,514,434.15
1916	2,160,000	4	....

The State tax authorized to be levied by the various county commissioners and the mayor and city council of Baltimore for the purpose of paying the interest and principal is shown as follows:

Amount authorized	Tax rates, in cents, per $100 of assessable property, for years succeeding sale of bonds.					
	First year.	Second year.	Third year.	Fourth year.	Fifth year.	Annually thereafter to fifteenth year.
$5,000,000	2	3½	4½	5½	6	6
$1,000,000	¼	½	¾	1	1	1
$3,170,000	3	3	3	3	3	3
$6,600,000	2½	2½	6	6	6	6
$2,160,000	1½	2	2¼	2¾	2¾	2¼

The first, second, and third issues were of the sinking-fund variety, but were issued subject to call after 10 years. The last two issues were of the deferred serial annuity type—that is, the first payment was to be made three years from the date of issue, and the other payments were to be made in such a manner that the average annual outlay for interest and principal would be to some extent equalized. Thus, the early payments for interest are relatively large and the amounts paid for principal are relatively small, and vice versa for the series maturing later. Maryland is the first State to adopt the annuity principle of bond retirement.

Local.—Special enabling acts are passed from time to time authorizing county bond issues. There appears to be very little similarity in these acts and no fixed policy governing the issuance of local bonds. In some cases the county commissioners are authorized and directed to issue the bonds, while in others a majority vote of the people is required before the bonds can be issued. Sinking-fund bonds have been authorized in some cases, while serial bonds have been provided for in others. The terms and interest rates also vary.



MAINE.

Development.—State support and participation in road improvement in Maine is of State-wide extent, is conducted on a fairly extensive scale, and is administered by the State highway commission. The principle of State aid had its beginning in 1901 and from that date State support in the form of money aid has been made a permanent policy.

Maine was the first State to make use of auto-license revenues as a fund to pay interest and principal of State bonds issued for road improvement purposes.

A trunk-line system comprising 5½ per cent of the total road mileage of the State and which connects all counties of the State has been designated by and is being improved by or under supervision of the State highway commission. It is reported that this system of roads when completed will serve 74 per cent of the population and 73 per cent of the assessed valuation of the State.

At present about 3,250 miles, or 14 per cent, of the total road mileage of the State has been hard surfaced, the cost having been borne by all road forces of the State, namely, State, county, and towns.

In 1916 a total of $3,167,215 was expended by all road forces of the State. Of this amount, $1,055,250 of State funds and $453,518 of local funds were expended by or under the supervision of the State highway commission. Thus the State supervised the expenditure of 47.5 per cent of the total and contributed about 33 per cent of all expenditures. During 1917 the total expenditures from all sources amounted to $3,244,982.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown herewith.

State.—At the head of the road forces of the State is the State highway commission composed of three members appointed by the governor for terms of three years. The commission selects, with the approval of the governor and council, the chief engineer, who serves at their pleasure, and who acts as the executive official of the commission.

The commission has power and is required to select systems of State and State-aid highways; to issue and enforce rules and regulations relative to construction and maintenance of such highways; to direct the expenditure of all State funds provided for road purposes; to enter into such contracts as may be necessary to carry out the provisions of the laws of the State pertaining to State and State-aid highways; and to advise local officials on such road and bridge matters as may be brought to their attention.

The chief engineer, with the approval of the commission, has the right to employ at a compensation fixed by them such force of assistants and clerks as may be required.

County.—Authority over road affairs in counties is vested in a board of three commissioners elected for terms of six years, one being elected biennially. The board has the power upon petition to lay out, alter, or discontinue highways and to expend funds thereon for their improvement. In unincorporated townships—i. e., "wild land" townships in which there are practically no settlers, the board has full control over all road matters not otherwise delegated to the State, and has the power to appoint suitable agents to superintend the construction and repair of roads.

Town.—Authority over town road affairs is vested in a board of selectmen consisting of three, five, or seven elective members. The board so constituted has the power to levy taxes voted by the towns at their annual meetings for road or highway purposes, and to employ proper persons to carry out the work. The board may exercise the right of eminent domain over lands containing road building materials suitable for highway purposes, and may enter into contracts or agreements with the State highway commission, when so authorized by vote of the town, relative to improvement of the roads under their control.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 23,537 miles of public road in Maine are divided for the purpose of fixing responsibility for control, construction, and maintenance into three grades, viz, State highways, State-aid highways, and county or town highways.

State Highways.—These comprise about 1,300 miles of road designated by the State highway commission of which 550 miles were improved or contracted for on January 1, 1918. Such roads have been or are to be constructed by the State highway commission with State funds. They are maintained by the State highway commission, the town in which any State highway is located contributing $60 per mile per annum toward the maintenance expense.

State-Aid Highways.—Sections of State highways or roads of local importance improved with State and local funds under supervision of the State highway commission are called State-aid highways. The roads comprising this system are designated on the initiative of town or county boards by a joint agreement between the board and the State highway commission. Maintenance is executed by the State highway commission with State funds, the local board contributing not to exceed $30 per mile per annum. Of the State-aid system 1,560 miles were completed or under contract on January 1, 1918.

State aid is allotted according to a scale provided by the State law and only when the town agrees to provide an amount required of them. The allotment law in general provides that the State will furnish aid ranging from an amount equal to the local contribution to an amount equal to two and two-thirds times the local appropriation. The ratio and the amount of local contributions are dependent on and vary inversely with the assessed valuation of the town. Under certain circumstances the amount of local contributions may be increased up to fivefold, in which event the State similarly increases its regular pro rata contribution and gives a bonus of 25 per cent of the extra aid.

County or town roads comprise all other roads of the State. They are improved and maintained by the town in which they are located.

Bridges on State highways or other improved highways when so decided by a joint board composed of the State highway commission, the county commissioners, and the municipal officers of the city or town in which the bridge is located, are built by the State, the costs being apportioned 50 per cent to the town, 30 per cent to the county, and 20 per cent to the State.

State highways, State-aid highways, and such local work as may be delegated to the State highway commission may be executed by force account or by contract. Such contracts may be let with or without advertising when deemed by the commission of advantage to the public interest to do so. Convict or prison labor may be employed on highway work, but it has been used only in two or three instances.

Surveys, plans, and specifications for all work involving the use of State or Federal funds are executed by the State highway commission. When let by contract each bid must be accompanied by a certified check payable to the treasurer of the State in an amount equal to 10 per cent of the bid. Towns may bid on and receive contracts through proper officials, and when they secure contracts they are not required to provide bond. Otherwise the successful contractor files a bond in an amount specified by the State highway commission.

During construction, the work is under the inspection and supervision of a resident engineer assigned by the chief engineer. Monthly payments to the contractor are based on estimates prepared by the resident engineer and approved by the chief engineer.

Final payments are made in a similar manner when the road has been completed and accepted by the chief engineer or his authorized representative.

REVENUES.

State.—State revenues for 1917 were provided by (1) direct appropriation of $300,000 by the legislature for State-aid highways, and $100,000 for bridges; (2) $300,000 from the proceeds of a $2,000,000 bond issue, which funds are available for State highways; (3) appropriation as aid to poor towns, $145,000; (4) receipts from the imposition of a license on motor vehicles and the operators thereof. These last funds are: (*a*) To pay interest on the bonds issued, (*b*) to pay principal of bond issue, (*c*) to support State highway department, (*d*) to maintain State and State-aid highways. There was transferred from this fund, by order of the governor and council, $162,876.58 for State highway construction in 1917.

Effective in 1918 a State-wide tax of 1 mill on each dollar of assessed valuation will be levied on all taxable property in the State, the proceeds of this tax being available for State and State-aid highways. It is expected that this tax will yield $521,000.

County and Town.—Funds for road improvement are raised by taxes on real and personal property at rates fixed by the board of selectmen and by a poll tax levied on male inhabitants not exempt by law.

Bonds may be issued by towns in an amount equal to 5 per cent of the total assessed valuation of the town.

State bonds of the serial type payable within 41 years from the date of issue and bearing not to exceed 4 per cent interest may be issued in amount not to exceed $500,000 a year or a total of $2,000,000 outstanding at any one time. The interest and principal of such bonds are paid from State motor vehicle fees. The total State bonds outstanding at present amount to $1,800,000.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

Dept. Bul. *53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913
136. Highway Bonds
220. Descriptive Catalogue of Road Models of Office of Public Roads.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
370. The Results of physical Tests of Road-Building Rock.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials
583. Report on Experimental Convict Road Camp, Fulton County, Ga
586. Progress Reports of Experiments in Dust Prevention and Road Preservation. 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETIN.

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

YEARBOOK SEPARATES.

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10. No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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*Department supply exhausted

*Department supply exhausted.

Resumption and Extension of Highway Construction

WE must resume as quickly as possible, in full measure, the operations under the Federal Aid Road Act. You understand why they had to be contracted during the war. It is highly important that they be resumed. I need not emphasize before you the fact that good roads are prerequisite for better agriculture, for orderly distribution, and for a healthful and attractive country life. From unexpended balances of Federal appropriations for the last few years, from State funds beyond what was necessary to meet the Federal allotments, and from amounts available during the current fiscal year, we shall have for expenditure during the calendar year approximately $75,000,000. Next year, if all the balances should be expended during this year and we should have to rely solely on the funds accruing next year, we shall have from Federal appropriations about $20,000,000 and probably more than this amount from State sources. The States, in addition, will expend sums in excess of what they have assigned, or will assign, for Federal aid road projects. Still, it seems to me that we should take a further step—take this step not only because of the importance of good roads, but also because of the desirability of furnishing worthy projects on which unemployed labor during the period of readjustment may be engaged. There will be many things suggested for which Federal and State funds will be sought. Some of these will be unworthy. Clearly such public works as roads are worthy, and it would be in the public interest to make available larger appropriations from the Federal Treasury, to be used separately or in conjunction with State and local support.

There need be no delay in the execution of such a program. The Nation has already provided the machinery in the Department of Agriculture and in the State highway commissions. The Federal Aid Road Act was fruitful of good legislation and each State in the Union now has a central highway authority with power and funds to meet the terms of the Federal Act. The two agencies, in conjunction, have been engaged in devising well-considered road systems and in making surveys, plans, and specifications. The task will be one of selection and those roads should be designated for improvement which are of the greatest economic importance, with due regard to such military and other needs as are proper for consideration. There is no necessity for any departure from this scheme. The suggestions made have been canvassed with the President, the Secretary of War, and the Postmaster General, and they are in accord with the view that additional funds should be made available to this department and that they should be expended through existing machinery.

From an address by Secretary Houston.

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BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 9 WASHINGTON, D. C. JANUARY, 1919

BITUMINOUS MACADAM, SHOWING CUT AND DRAINAGE, BALTIMORE COUNTY, MD.

In this number "Public Roads" presents papers read by members of the American Association of State Highway Officials at the recent convention of that Association in Chicago. While the Bureau of Public Roads takes no occasion either to endorse or differ from any of the statements made in these papers it is believed that they are of sufficiently great interest to the thousands of readers of "Public Roads" who could not be in attendance at the convention to warrant their reproduction.

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both houses of Congress. Others desiring to obtain "Public Roads" can do so by sending 15 cents for each numbers or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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BUREAU OF PUBLIC ROADS

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The Federal Aid Road Law and Changes Suggested by its Practical Operation

THOMAS H. MacDONALD, Chief Engineer Iowa State Highway Commission.

THERE is a clamor for improved roads—improved roads at once and everywhere. No other word expresses the situation. Sometimes the clamor seems to admit of an interpretation like this: "Improved roads anywhere, if at once."

Improved roads are needed, and more, they are needed at once. The lack of improved roads made itself keenly felt as one of the weaknesses of this Nation during the period of the war. The determination to overcome this weakness by an accelerated program of highway improvement exists as a general sentiment and finds expression in a multiplicity of ideas, some sane; some the merest froth. Road improvement is not peculiarly a reorganization or reconstruction problem developed by the war. There is no fundamental difference in the service which improved roads will return to the public now compared to the service which improved roads rendered before the war. The difference is mainly one of degree. More people have found more uses for motor vehicles, particularly more motor trucks, resulting in a demand for more service from the public highways. The difference, as stated, is one of degree.

THOMAS H. MacDONALD

THE HIGHWAYS OF THE FUTURE.

From the engineering side it has been clearly shown that the roads of the future must be built to carry a larger number of units, heavier maximum loads, and higher speeds. From the administrative standpoint, the radius of utility of the motor vehicle has been so greatly extended as to demand a continuity of routes and an arrangement of highway systems that are not limited by municipal or even State boundaries. We have the post war problem, then, and the prewar machinery with which to handle the problem.

There seems to be a disposition in some quarters to overlook existing agencies and to pass the responsibility for undertaking the super-program of road improvement demanded along to the Federal Government. The activities and accomplishments of the Federal Government during the past two years are undoubtedly worthy of this compliment on the part of those who desire forthwith and at once the consummation of their ideas; that is, good roads everywhere. This attitude, however, will stand the keenest and coldest analysis, in the light of past experiences in turning over matters of this character to the Federal Government without its own consent. The Federal aid road act we have. It is the product of cooperation. It is the first law of any importance ever secured from Congress dealing in a broad way with the improvement of the public roads of the United States. We have in it a foundation on which to build, and on close analysis we have found it a worthy and suitable foundation.

It will be recalled that at the Chicago convention of this association in December, 1915, three years ago, careful consideration was given the proposed bill in the form prepared by the executive committee. Prior to the Chicago convention the bill had received a favorable vote by letter ballot from a majority of the then organized 37 State highway departments. At the Chicago convention none of the principles written into the bill were changed and only minor changes were proposed. The measure as it appears on the records of that convention, with a few modifications, met the approval of the Secretary of Agriculture and was passed almost unanimously by both houses of the Sixty-fourth Congress. It became effective immediately when signed by President Wilson on July 11, 1916. In six months, therefore, from the final consideration of the proposed measure by this association, Congress had approved the plan as submitted and had definitely and substantially committed the Federal Government to a policy of participation in the improvement of rural highways. It is within the record, therefore, to say that this act three years ago represented fairly the judgment of all of the State and Federal departments intrusted with its administration in a degree rarely found in legislative acts affecting so many different administrative units.

LAW RESULT OF COOPERATION.

As it stands to-day this law is the tangible product of all the yesterdays of endeavor to secure by substantial financial support recognition on the part of Congress of the importance of the public highways to the national life, and of the responsibility of the Federal Government to assist in their permanent improvement.

The history of attempted road legislation is long. The agitation was so general that speeches in favor of Federal participation became standardized from one end of this country to the other. Perhaps no other legislation actually secured required greater subjugation of personal and selfish motives. The Federal aid road act embodies something finer than the realization of any sectional idea. It typifies the spirit of cooperation—cooperation between the individual States, between the several groups of States, and between the States and the Federal Government. It is indicative of the results which may be secured by united endeavor by this association and is, judging by past experiences, the method which must be followed in securing a modification of Federal legislation on this subject.

Within six months after the majority of the State highway departments agreed between themselves and with the Secretary of Agriculture upon a reasonable plan for Federal participation in highway improvement, that plan was adopted and vitalized by an appropriation of $75,000,000, a sum sufficient in prewar times to forecast the inauguration of a permanent policy.

In order to meet the terms of the Federal aid act, it was necessary for 11 States to form new highway departments and for all the remainder of the States to secure appropriations or modifications of existing statutes.

SUCCESS OF FEDERAL AID ACT.

Almost before the States were ready to operate under the act we were involved in the war with its consequent disorganization of highway departments and almost complete shut-down of all highway activities. We have not, therefore, had any fair trial of the Federal aid road act under reasonably normal conditions.

We may assume that the plans as proposed was fairly acceptable to a majority of the State highway departments. The plan was not founded upon precedents, for there were no precedents. We have not had sufficient experience as yet to judge of the ultimate results which will be produced. It seems to me, however, that this measure, even under abnormal conditions, has been of the greatest service to a majority of the State highway departments. It came at a time to assist greatly in consolidating and holding against the attacks of unfriendly interests the positions which had been attained by many of the departments and placed the sterling mark of approval upon highway engineering and administration developed by the individual States. The recognition by Congress of the individual State highway departments and the demand in the post-road act that the State manitain an efficient, sufficiently supported State highway department has done more to establish highway work on a sound and certain basis than any other factor. It is doubtful if the executive committee or the membership of this association as a whole realized, when the Federal aid act was given final consideration, the extremely varied conditions this act would be called upon to meet in the various States.

STATE DEPARTMENTS ON LAW.

It has been my good fortune in preparing for this discussion to receive from 35 of the 48 State highway departments a discussion of their experiences up to this time with this act. These letters describe so many and such varied sets of conditions that my admiration for the post-road act has been greatly increased by the few pronciples embodied in the act which have been found to work any hardship even under the extreme range of conditions.

Take for instance the statement from Nevada. Mr. Cottrell, State highway engineer, says "Nevada is the only State in the Union having less than one person per square mile of area. Eighty-eight pe cent of its area still remains with the Federal Government. We have in all only four rural free-deliver routes."

Mr. Heath, acting commissioner for Kentucky writes: "The eastern section of Kentucky needs more roads than any other part of the State. Most of the construction must be thorough entirely new country."

Mr. Brown, acting State highway engineer for South Carolina, says: "It has been our experience in this State in more than one case that bridges and trestles through swamps were of very great importance, both locally and as links of through highways."

It is a far cry from conditions thus described to the established road systems of Massachusetts, Connecticut, and other of the Eastern States.

It is, therefore, very remarkable that there are contained in the reports from the 35 State highway departments, representing 75 per cent of all of the States, criticisms of only three features which are embodied in the Federal aid measure.

These features are as follows:

1. The interpretation placed upon the post-road equirements by the Solicitor of the Department of Agriculture.
2. The limitation of $10,000 per mile to cover Federal participation.
3. The amount of the appropriation carried.

THE POST-ROADS PROVISION.

After a careful consideration of the reports from all of these States, I am unable to find in any statement of the limitations or handicaps which the departments have suffered any other reference to the principles of the Federal aid road act itself. The verdict on the post-road limitations is nearly unanimous. There are perhaps four States which report no difficulty encountered as yet, but the verdict of the remainder is unanimous and certain. The difficulty with this feature has been very general. It has existed in New Jersey and Massachusetts as well as in the States of the middle and far West.

It is doubtful if this feature merits any considerable discussion. Mr. Cotterill, chief engineer for the Washington State department, says, "Assuming therefore, that the post-road feature must stand, it should, either by amendment of the act or regulation, be extended to include any sections of main highway whose improvement will make same better adapted for post road purposes, present or future. Revision of location is a vital prerequisite of any permanent improvement, and the Federal-aid law and regulations should not tempt away from revised locations. It ought to be sufficient that the project generally follows existing post roads without insistance upon identity of locations with all local detours, and without arousing unnecessary local jealousies and controversies by a demand for specific affidavit from local officers without authority to deliver the goods."

It was clearly the intent of this association to secure a measure which would allow the improvement of any road which would fit into a system of main highways, State or National, and any interpretation which is placed upon the Federal aid act which limits in the slightest degree the use of funds for this purpose, or requires unnecessary work on the part of the departments or arouses local discussions and petty bickerings, is foreign to the purposes of the act. It is to be regretted now that this measure was not based upon the general-welfare authority of the Constitution rather than upon the post-road feature. It is certain, however, that to a majority of the State highway departments nothing less than the elimination of all evidence relative to post-road features of roads proposed for improvement will be satisfactory, and any arrangement which can receive the support of this association must produce this result.

OTHER FEATURES TO BE CHANGED.

The objection to the $10,000 per mile limitation was supported by only one or two of the highway departments. As would be expected, this feature would only handicap the construction of the highest type of roads. It must be remembered that this act was passed when prices were materially lower and that the $20,000 limit on an equal basis of Federal and State funds seemed to provide fairly for all reasonable construction. Commissioner Duffey of New York, says, "The question of the maximum amount per mile which the Federal Government will contribute at the present time, taken in conjunction with our own State law, allows no construction of Federal-aid roads in this State, as the roads which we desire to build can not at present be built for $20,000 per mile. Even though the close of actual warfare is attained, it is too early as yet to draw any definite conclusions as to the time when more normal condition will prevail and materially lower prices for labor and material be reached. If the date when these lower levels are to be reached is long deferred, it is quite probable that the demand for permanence of construction will urge the commencement of the work even though the cost be very high. In that event the maximum limitation of $10,000 per mile would be objectionable."

The third feature, that is the amount of the appropriation carried by the post-road act, was referred to by only one or two departments, but this seems to me to be the most essential criticism of any. Mr. Hirst of Wisconsin, says, "The amount of Federal aid is entirely inadequate. It does not make very much difference financially what each State gets, but it is a fact that the expectations of the people have been aroused as to Federal-aid construction and the Federal-aid funds available are very disappointing. For the moral effect we believe that the Federal appropriation should be made at least $50,000,000 each year."

The Federal-aid funds have been a wonderful stimulus in securing the appropriations by States and counties and it naturally follows that the greater the Federal appropriation the greater will be the total of the funds available for securing the roads which are demanded. In Iowa we find that the counties are voluntarily contributing additional funds, which, for projects already approved, will average approximately the same amount as the Federal appropriation, thus distributing the burden, one-third Federal, one-third State, and one-third county.

PROPOSED AMENDMENTS TO ACT.

These three features cover all of the amendments which are needed to the Federal aid act itself to meet all of the objections which have been voiced by 75 per cent of the State highway departments.

There has been sent out by the Bureau of Public Roads recently a draft of a measure which proposes amendments to the act, as follows:

By striking out the word "may" in section 2 and substituting the word "can." With this amendment section 2 in part would read, "The term rural post road shall be construed to mean any public road over which the United States mails now are or can hereafter be transported."

The second amendment proposed is to strike out the limitation of $10,000 per mile in section 6. This would leave the Secretary of Agriculture free to approve any road project for which one-half of the funds were otherwise provided.

The third amendment proposes an increase in the funds available, as follows: $50,000,000 immediately available; $75,000,000 available July 1, 1919; $75-000,000 available July 1, 1920, and $100,000,000 available during each of the years 1921, 1922, 1923, and 1924. These sums are in addition to the sums named in the act, which are as follows:

For the fiscal year ending June 30, 1919, $15,000,000.

For the fiscal year ending June 30, 1920, $20,000,000.

For the fiscal year ending June 30, 1921, $25,000,000.

These amendments to the post road act should eliminate every criticism of the law itself which experience up to this time has produced.

EXCEPTIONS TO REGULATIONS.

The rules and regulations promulgated by the Secretary of Agriculture for carrying out the Federal aid act have been confused by some departments with the law itself. There are a number of exceptions taken to the regulations, some of which are meritorious, some clearly less the fault of the Federal department than of the State departments themselves, but all are of such a nature that no difficulty should obtain in securing the proper adjustment. These are briefly summarized as follows:

1. Conflicts between the State laws or the State constitution and the Federal aid requirements.

2. Limitation or refusal to allow the expenditure of Federal aid funds for certain costs entering into the completed roads, including preliminary engineering, right of way, advertising for bids, and like expenditures.

3. Plans, specifications, and survey requirements. More latitude is desired in the use of scales, in the number of cross sections, in the engineering data required for the submission of projects, and in the estimates of quantities.

4. Adherence to standard specifications in instances where a deviation is desirable.

5. Difficulties or delays encountered in securing approval of plans, specifications, and estimates, or of obtaining quick decisions or of obtaining the approval of the district engineers of monthly vouchers.

Many of the causes of complaints would be eliminated by the granting of greater authority to the district engineers of the Federal department.

Under the above classification can be grouped nearly every complaint which has been mentioned by the departments. There does not seem to be any difficulty included in this list which can not be settled satisfactorily by reasonable revision of the present rules and regulations, and it is my opinion that the Secretary of Agriculture and the Bureau of Public Roads would be willing to consider these matters on their merits. This seems to be a work that the executive committee of the association, having in its possession the statements from the departments of their difficulties, could take up at once and secure an adjustment of all meritorious grievances. A plan of this character seems to me to possess sufficient merit to adopt as a permanent policy. It would require only a little effort on the part of the Federal and State departments to perfect a scheme of cooperation to such an extent that there would be practically no difficulties encountered.

It would not be proper to close this discussion without referring to the many statements made by the State departments relative to the cooperation and pleasant relations which have existed between the departments and the Federal department and its district engineers.

LAW IS LIBERAL AND A SUCCESS.

As stated in the first paragraphs, the present Federal aid law is the product of cooperation. From the expressions of the highway departments this cooperation is being maintained, and generally a cordial spirit between the State and Federal departments prevails. From a careful investigation of the whole subject I have become personally convinced that the Federal aid act is as liberal a measure as can be expected; that the States are bound by few limitations, and that where rules and regulations exist which fail to meet the general purpose of the act itself, or which are productive of delays or embarassments or misunderstandings between the State and Federal departments, these should be eliminated in conference. It is not to be expected that the Federal Government will appropriate large sums for the improvement of public roads of the Nation unless it maintains a method by which it insures to its own satisfaction the proper use of these funds.

The demand upon Congress from every side for large appropriations for all purposes is tremendous and for my part I am convinced that no matter how meritorious is the appropriation for that purpose we will succeed in securing greater recognition from Congress if we maintain the spirit of cooperation which now exists between the States and the Federal department.

License fees for Motor Vehicles and Drivers and How to Grade Them

H. ELTINGE BREED, First Deputy Commissioner of Highways, New York.

THOSE who benefit from an improvement should be the ones to pay for it. Like many another obvious truth, that easy-sounding statement conceals the kernel of our perplexity. Who benefits by improved highways and in what proportion? The question involves the economics of taxation; the answers to it are as radically opposed as Kitchin and Lodge.

They run the gamut from those who would place the entire cost of highway construction and maintenance upon the direct users of the roads, to those who would exempt them and make the general public foot the total bill. In between are the various degrees of compromise, all of them advocating, in different ratio, some tax on the public and some on the vehicles. To prepare the way for this middle group let us briefly consider the arguments of the two extremes. Many of them appear in replies to a questionnaire that I sent to a number of State highway officials and to representatives of automobile associations and industries.

THE PLEA THAT PUBLIC PAY TAX.

The strong plea for exempting the direct users of roads and placing the entire cost upon the public is of course that the public is ultimately the great beneficiary.

I may never own a car or ride in one, but when my child is taken critically ill, his life may depend upon the speed of the good road over which the doctor can reach him. Shall I hesitate to pay my share toward it?

I may never have letters to send or goods to export, yet inevitably the life of my household and business depend upon the receipt of supplies from without. Shall I not help pay for the route over which they travel?

Even though I may never use the public schools I gladly pay the school tax, because through education it enhances the life of the community, and hence my own welfare.

I pay for police and fire protection though personally I may never need either, and I don't demand that people whose houses burn up, or who have burglars arrested, shall pay a special fee. Should I not be willing, as one of the public, to pay for the public benefits derived from good roads, especially as I am bound to receive from them not only a share in the general good, but direct personal advantages?

The argument sounds convincing. It is ably supported by Mr. George Diehl of the American Automobile Association.

H. ELTINGE BREED

An interesting suggestion for application of the entire tax upon the public is made by Mr. Ellis Dutton. Land bordering the highway, whose value is directly increased by it, shall carry the greatest burden of expense; contiguous lands and the general public less, proportioned as far as possible upon the benefits they receive. Says Mr. Dutton: "In every case where streets or roads are paved the increased value of the property is more than the cost of the improvement. Shouldn't these benefited lands pay for the paving * * * and in less proportion contiguous lands and the general public?"

But as in the case of so many other convincing arguments, there is a practical difficulty, not insuperable perhaps, but considerable. The traffic demands for and upon highways are greater than the tax-paying power of the public can sustain. More and more traffic—an increase in New York State of 390 per cent in motor vehicles in the last seven years—more need for new routes and good maintenance, higher and higher taxes, until the point is reached where the increased cost of the roads does not yield the taxpayers a commensurate return in public benefits. The gain accrues to private pocketbooks. Thence we swing to the opposite extreme that says that the motor vehicles using the roads and directly profiting from them should be the ones to pay for them. I purposely omit horse-drawn traffic here, as being an increasingly negligible factor upon our highways.

THE ILLINOIS MOTOR-TAX IDEA.

Illinois is the chief exponent of taxing motor traffic for the entire cost of the highways.

The arguments advanced by Mr. Bradt of Illinois in favor of their arrangements are:

1. The practical difficulties of raising money through a general public tax. The political party in power, particularly in election year, is so anxious to keep down taxes, that it is loath to secure funds for absolutely necessary work. The tax burden in Illinois is already very heavy.

2. The greatest benefits from the roads accrue to the direct users of them. Motorists gain directly through the lower cost of running on good roads. Hence the user should pay.

3. The public really pays a share through the increased cost of service and commodities received over these highways.

On the strength of these arguments, Illinois has authorized bonds for $60,000,000 for highway improvement, all of which will be paid from automobile, dealers, motor cycle, and chauffeurs' license fees, the greater part being derived from automobile fees. The system to be built from this sum will extend 4,800 miles, and, it is estimated, will carry 40 to 50 per cent of the total State traffic. It comprises, however, only 5 per cent of the total road mileage. The other 95 per cent will have to be maintained and improved through general taxation.

So even the State that has gone farthest in taxing vehicles for highway purpose, has stopped short of the ultimate, 95 per cent in mileage, and 50 per cent in traffic.

USERS CAN NOT BEAR ALL COSTS.

The practical objections to putting the whole cost of the highways upon motor car users are obvious. In the first place, even if it were practicable, it would not work—which is not quite so much of a bull as it sounds. It would not work because of argument No. 3. All cars engaged in any kind of public service—by far the greater and more destructive number when you include the motor trucks—would immediately charge the expense of the fee to the cost of their service, increasing the price to the consumer, so that the public would be paying just the same, only a little more so, for the benefits it receives via the highway route. Indirect taxation may tickle the palate, but it is fundamentally bad for financial digestion. The relatively small number of car owners who do not perform any public service for which they charge would bear the brunt of disproportionately high taxation. This immediately raises the question of how far we believe in class taxation. Is it, or is it not justifiable?

Moreover, I don't believe it is generally practicable to raise highway funds exclusively through taxation of vehicles. It would tend to limit the number of vehicles, and the fewer these were the more each one would have to pay, until the limit that any one could endure would be reached. Then the roads would have to suffer—less new construction, poorer maintenance, until the public realizing that the loss of good roads was costing far more than the taxes necessary to sustain them, would rise up and demand that they be continued.

A PRACTICAL WORKING BASIS.

It is really the theory of marginal utility that adjusts the difference between the two extremes and offers us a working basis. The public is willing to pay up to the margin where the utility it receives from the road compensates the money outlay in taxes. Beyond that it cannot economically go. But so great is the destruction of the roads under heavy traffic that taxes on this basis will not meet the entire cost of maintenance and desirable new construction. The difference must probably be met by a tax on vehicles. Now, the vehicles are willing to pay up to the margin where the tax levied upon them is commensurate with the especial value that they, as direct users, receive from the road in distinction from the nondirect-using public. Believing therefore that both classes of beneficiaries should contribute toward the support of highways it remains to adjust the balance between them.

The point of marginal utility for the public seems to be reached at paying for the construction of new roads. The cost of these is great, so is the immediate benefit derived by the public. More exactly than such balances can usually be made, the point of marginal utility for the vehicles seems to be reached at paying for maintenance. The cost of maintenance is great—so also is the damage done by motor vehicles to roads for which the public has paid. I make these two statements a priori, from a study of cost data and of the means taken by the different states to raise the necessary funds for highway purposes. They are, of course, open to dispute. I offer them as an hypothesis, because motor truck fees must be considered in relation to the objects for which they will be used.

LET FEES PAY FOR MAINTENANCE.

If we consider the fees in relation to maintenance, Connecticut offers us some interesting experience. Mr. Bennett, the commissioner there, is working on the theory that the income from motor fees should approach the outgo for maintenance.

Here are the schedules of Connecticut's heaviest revenue producers in fees:

	Per annum
For passenger cars, per horsepower	$0.50
For commercial vehicles:	
Up to 1,000 pounds	11.00
1-ton	15.00
3-ton (an increase of $5 per half ton)	35.00
5-ton (an increase of $10 per half ton)	75.00
7-ton (an increase of $12½ per half ton)	125.00
7½-tons	150.00
8-tons	200.00
(Then for each additional ton or a fraction over a ton, $100.)	
Each motor cycle	2.00
Each chauffeur or operator	2.00

Here are the schedules of New York's heaviest revenue producers in fees:

	Per annum
Passenger cars:	
25 horse power	$5.00
25 to 35 horse power	10.00
35 to 50 horse power	15.00
50 horse power or more	25.00
For commercial vehicles:	
2 tons or less	10.00
14 tons (an increase of $5 a ton)	70.00
(And for each ton over 14, $10 per ton.	
For trailers:	
2 tons or less	5.00
2 to 5 tons	10.00
5 to 7 tons	15.00
7 to 10 tons	20.00
10 to 14 tons	30.00
(And $5 for each ton above 14.)	
For passenger omnibuses:	
Up to 5 passengers	15.00
Not less than 6 passengers nor more than 7	24.50
Not less than 8 passengers nor more than 10	30.50
Not less than 11 passengers nor more than 16	43.00
Not less than 17 passengers nor more than 20	52.00
Not less than 21 passengers nor more than 22	55.00
Not less than 23 passengers nor more than 26	61.50
Not less than 27 passengers nor more than 30	67.50
(And an additional $2 for each passenger over 30.)	
Motor cycles	2.50
Chauffeurs:	
First year ($3 for license, $2 for examination)	5.00
Renewal	2.00

According to motor-car owners with whom I have talked, these fees are paid willingly, both as a matter of abstract justice in repairing the damage done by the vehicles themselves, and as a matter of personal interest to the motorist. Through the payment of fees for maintenance of good roads they assure themselves that they will lower operating expenses, decrease hazards, and curtail delays.

PROPER USE OF FEES LEVIED.

But here is an important point in considering motor-car fees in relation to maintenance: **The cost of maintenance depends upon the efficiency of your highway department.** Put in incompetents or grafters, and the fees will either go beyond bounds or the maintenance will fall short. The general public is not yet educated to knowledge of and insistence upon the best use of the taxes it pays. It is all up to the motor-car users and industries to see that the money for highway purposes be expended by honest men of proven ability. Whether they like to or not they must concern themselves in politics to the extent of securing good highway men in State service, for the success of their business depends upon the success of the roads and the success of the roads depends upon highway administration.

For instance, for years Mr. Bennett has been building in Connecticut durable types of pavement with maintenance charges of $100 to $200 per mile per year—a very different proposition from laying waterbound macadam with a maintenance of $1,000 a mile or upward a year under heavy traffic. If motor-vehicle fees are to cover maintenance wisdom must be shown in laying permanent types of pavement for heavy traffic, so that repairs will be kept at a minimum.

The maintenance itself must be well advised and executed. Millions of dollars can be squandered on poor materials or work delayed or done at the wrong time. The proverbial stitch saves nine. The motorist must insist that repairs be promptly made, so that his fee is used to the limit of advantage. In justice to himself he can not shunt off the responsibility upon some unknown official.

In New York State motor fees are a trifle lower than those in Connecticut. For the last two years they have almost covered the cost of maintenance. Last year fees aggregated $4,284,114; maintenance was $4,939,916. For nine months of this fiscal year ending November 1, fees were $4,571,852.75, while maintenance was over $54,000 less. Maintenance is high now because almost all our earlier roads, built to sustain traffic up to 3 tons, are protesting against traffic ten times that weight. The maintenance includes many complete resurfacing jobs done with durable pavements. As we build better roads maintenance should decrease, even with increase of traffic. Motor-vehicle fees can then be lowered. They will probably be close to the scale now advocated by the Highway Industries Association in its uniform motor-vehicle traffic law.

TRUCK LOADS MUST BE LIMITED.

Another important point to consider in relation of motor-truck fees to maintenance is limitation of damage that any one vehicle may do to your pavement. It is manifestly unfair to expect all motorists to pay for the destruction done by a few excessively heavy trucks, as unfair as to expect the public to pay $50,000 a mile for new roads to sustain such trucks. There must be an arbitrary limit of load for which we can design our roads. Otherwise, as fast as they are built, roads will attract to themselves traffic heavier than they are designed to bear. The road and the load will be forever outstripping each other, with great economic loss both of the original investment in the road and in the appallingly high maintenance. In addition to regulation of weight of load there must also be regulation of other destructive factors, such as width and kind of tires, springs, speed, etc. If, after our roads are built in accordance with these regulations, it seems in course of time desirable to put much heavier loads upon them, we may well consider the suggestion made by Mr. Whinery that we lay narrow-gauge tracks on either side of our pavement to carry the heavy trucks.

With these regulations, it is obviously only fair to proportion the fee to the vehicle in accordance with its probable requirements upon maintenance funds. It would not be fair to tax the little two-passenger flivver the same amount as the 12-ton truck.

Mr. Nelson P. Lewis, chief engineer, board of estimate and apportionment, New York City, says: "The plan of grading the annual fee in proportion to the gross weight and carrying capacity is rational, and it might well go further and make the total width of the vehicle, where such width exceeds 7 feet, an element in the determination of this fee."

The fees should undoubtedly be graduated in accordance with the destructive factors to the road of the vehicle in question. Such a graduation is now made in many States.

A graduated scale of motor vehicle fees to cover the cost of highway maintenance necessitated by the cars themselves would not, I believe, fall too heavily upon any one. There are, of course, objections to it, but it seems to me the fairest adjustment yet made in taxation between the vehicle and the highway, the motorist and the public.

Day Labor and Force Account Work and the Bonus System in Highway Construction

CHARLES M. UPHAM, Chief Engineer, Delaware State Highway Department.

IN LOOKING into this subject I find that with some officials in certain sections of the country the method of doing work by day labor is very popular, but compiling the opinions of a great number of highway engineers, I think that the day-labor system has become unpopular and has the name of being costly and expensive and is without any of the advantages claimed for the contract system. The recent abnormal times that we have just passed through has compelled us to solve many problems. The day-labor system is one of the unsolved problems, though its name is old. During the last two years we have seen how in many instances the day-labor system has come to the rescue in emergencies, and in only a few instances has the work been carried on at abnormal cost. In many instances the reasons for high costs could undoubtedly be traced to other causes than the fundamental principles of the day-labor system.

WHEN SYSTEM GIVES GOOD RESULTS.

In localities where the supervision of the day-labor system has been efficient and the organization permanent, this system has produced and is still producing good results in construction at reasonable costs, costs that often are lower than those obtained by the contract system. Advocates of both the day-labor and contract system state that, properly controlled, their system produces better work. With proper supervision, inspections, and specifications the same results can be obtained either way, so that advantages can be compared merely to costs. By theoretical analysis it can be shown how the day-labor system is not as costly as the contract system, for it does not include the contractor's profits, nor the percentage that is included in the proposal for contingencies.

No State officials desire contractors to do work without profit, nor do they want the uncertainty of their plans and specifications that make the contractor's proposal become a gamble. It is accepted by all that the contractor should be paid the cost of his work plus a reasonable profit. In contract work there is generally figured a fair profit and also a percentage for contingencies that do or do not happen. These percentages are in addition to the actual cost of the work which in itself includes the pay for capable foremen, efficient supervision, and generally an allowance for the contractor's salary, provided this is not included in the percentage that is added to cover the profits. In other words, the contractor has provided for payment of all his expenditures plus a reasonable profit and an allowance for contingencies. If these contingencies happen the contractor should receive a payment covering them, but if they do not happen it simply makes a gamble out of the proposal, with the contractor the winner.

WHY CONTRACT SYSTEM IS FAVORED.

The day-labor system on the other hand does not include either of these charges of profit or contingencies, but it is the resulting expenditure of the actual cost of the work. Why is it then that day labor has not become universally adopted? Why is it that the day-labor system is looked upon with suspicion and turned down by engineers wherever there is a possibility of doing work by contract system?

Many cities, towns, and States began their public work by day labor. After a short period we find that in nearly every instance many of these cities, towns, and States have adopted the contract system to protect themselves, and they now get their work done at more reasonable costs.

That the fear of high costs resulting from the day labor system existed in earlier days is shown by the fact that early in 1800 we find engineers advocating the abolishment of day labor. It is said that Telford estimated the cost of work produced by the day labor system was 50 per cent higher than by the contract system. A railroad engineer informs me that he was somewhat surprised that the cost of day-labor construction was from 25 to 100 per cent higher than contract work. It is said that in 1909, Metcalf and Eddy went into the comparison of costs of day labor and contract work, and in a report to the Boston Finance Commission the result was in favor of the contract work. In a few other instances, however, the results show that the work done by day labor is cheaper than that done by contract, but these cases are in the minority. From these statements it seems that the results point in favor of the contract system for securing good work at reasonable cost.

DEVELOPMENT OF TWO SYSTEMS.

Before condemning the day labor system, however, a comparison of the development of each is interesting.

Probably the first so-called contracts were contracts for day labor. One instance is shown by a contract covering the digging of a canal in one of the Eastern States, in which it is stated that the contractor should furnish a certain number of men with satisfactory picks and sufficient shovelers to shovel the dirt picked by the first men, and sufficient wheelers to wheel the dirt shoveled. While this was a contract, it was a contract for day labor. The output in general was controlled by the number of men employed, but the amount of work the men did depended to a certain extent on the foreman or supervision. The next step was a closer control of the amount of work completed rather than the number of men working.

This was development in the contract system and made this system become popular among contractors. By securing the best supervision and using certain ingenious devices, short cuts in doing work by the contract system were developed and larger profits resulted. As for the owner, the work was completed quicker and at no greater cost. The contract system thus became popular for these various reasons, and especial attention was paid to this system both by owners and engineers. Specifications and detailed plans were developed and complete control of the work was secured. Costs were kept reasonable by the fact that the successful contractors maintained an organization of the best supervision and most up-to-date methods and machinery possible and consequently they could complete work at a comparative low figure and still make a profit.

ABUSE OF DAY-LABOR SYSTEM.

What became of the day labor system in the meantime? Cities, counties, and towns, and some States whose officials were changed every election would commence work by the day labor system. Many times the official would have had no experience in the particular line of work that he undertook, and for supervision he would fill these positions with his friends or political supporters. The result of this poorly organized, inefficient, supervision was high costs, and sometimes poor and faulty work. About the time the official became experienced and could have produced satisfactory work at reasonable cost, a house cleaning removed him from office and the same thing was done all over again by the next official. The day labor system has been abused by such methods as these, and there has never been any great attempt to develop this system to the degree that the contract system has been developed. The force account method may be a step in the development of the day labor system, and the cost plus percentage or the cost plus fee method is another stage in the development of the day labor system.

That the day-labor system is being abused is shown by the statement of a well-known contractor that I interviewed while looking up facts and information on this subject. This contractor has done considerable highway work and has six large contracts under construction. Five of these were day labor or force account work, the sixth was a straight contract. He spent practically all his time on the sixth contract and when asked why he did this remarked that the other five contracts were day-labor contracts and he could not lose anything, but because this was a straight contract, he must give it most of his time and also his best men. This is a bit of the abuse that makes day labor cost more than contract work, and this loose control and indifference by officials is the very thing that is condemning the day labor system.

HIGH COST DUE TO POOR ORGANIZATION.

High cost in day-labor construction was many times blamed on the principles of this system, but as a matter of fact the real reason was the inefficient organization and the lack of control. Because of the high costs, many cities and towns immediately condemned the method of day-labor system, and without any attempt to overcome the weak points in the system inaugurated the contract system, a system in which the control and methods had already passed through the experimental state and now was on a developed, definite, and sound basis.

With the same regulations and restrictions and the same personnel in day-labor system as in contract system, both should carry on the work at the same cost to the owner. In the contract system the contractor's profits and payment of the possible contingencies must be added to the costs. A few reasons why the day-labor system is expensive is because this system is generally harnessed by laws that limit the payment of the foreman and supervisors, and thus deprive this system of the privileges of the high class of supervision of the contract system. Many times the law also states just what the labor shall be paid. This again is a serious obstacle for the day-labor system to combat.

The limit of salaries of foreman and supervisors subject the day-labor system to many obstacles, for very often it happens in this day-labor system the limit in wages command supervisors and managers of only ordinary ability, or only partially experienced in their particular line.

The contract system on the other hand is not restricted as to obtaining the best supervision of labor. The successful contractor is a man of exceptional ability, one who represents the survival of the fittest. With this ability and the resources for efficient supervision the contract system is immediately put on a firm basis.

PRINCIPLE ITSELF NOT AT FAULT.

Therefore it seems that the day-labor system should not be condemned through reasons of the principles of the system itself, but should be passed through a period of development to the same extent the contract system has been developed. It should not be ridden with laws that combat the motives of the system. It is true a few steps have been taken in this development in the form of force-account work and in the cost plus percentage or cost plus fee system. The day-labor system will never be universally popular or successful until it is given the same freedom as the contract system and is controlled by the same standard of supervision and efficiency.

This subject is supposed to include a few words in regard to bonuses, presumably in connection with labor; but so much time has been taken in the discussion of the day-labor system, that I will only touch the subject of bonuses wherever it can be used in connection with developing the day-labor system. It is especially opportune to speak of the subject of bonuses in connection with the development of the day-labor system.

In practice we find that among contract laborers some men do more work and better work than others while they all may be receiving the same compensation. This does not encourage the men to do their utmost but is conducive to producing a matter of fact interest in their work. The ideal condition would be a piece-rate system, to pay all the men in proportion to the amount of work they turn out. This is not always possible in each individual case but it can generally be developed with groups of men at least.

BONUS SYSTEM PROVES EFFICIENT.

By analysis the bonus system means a piece-rate system with a minimum guarantee. An interesting fact that happened during the past construction season describes one of the advantages of the bonus system: Two contractors, 7 miles apart, on the same road, having practically the same territory from which to draw labor, were constructing a concrete road. Both contractors at the beginning paid $4 per day for labor The one added a bonus system, the other stated he would raise the wage if necessary. The man paying the bonus averaged $4.25 per day in paying for his labor. Consequently he soon drew more and better labor. The second contractor seeing his men leave, raised his wages to $4.25 and then to $4.50, and finally to $5, but at no time did he complete as much work with the same number of men as the contractor that paid $4 minimum wages plus a bonus. This was really the piece-rate system with a minimum guarantee.

The bonus system made each man a sub-contractor and his wages depended on his efforts and the amount of work completed. If the day labor system of doing work could have the benefit and advantage of this spirit among its labor, a great step in developing the system would be taken.

SYSTEM SHOULD BE DEVELOPED.

While the idea of bonuses seems to be old, it has not been used to any great extent especially among contract labor. The only reason for this seems to be that this branch is another detail not yet developed.

To develop the bonus system among contract labor, as it has been developed in the industries, may at the same time make it possible to produce a labor that can be used successfully in the day labor system and we may then expect many of the present day difficulties for the successful use of the system to be overcome, and we might possibly find the same efficiency and control in this system as is found in the industries. The operation of that system of day labor that has been found so costly and so unpopular among engineers, may, with the help of the bonus system be developed on an economic plan, closely approaching in practice the theoretical principles of the day labor system, and becoming a popular method of carrying on highway construction.

The Present Situation, and How We Are Meeting It in New England

Col. W. D. SOHIER, Chairman Massachusetts Highway Commission.

THE New England States—Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut—have an area of about 62,000 square miles, or a little more than 2 per cent of the area of the United States. They are quite thickly populated and have developed large industries.

New England contains over 7 per cent of the population and over 10 per cent of the entire valuation of the United States, with only 2 per cent of the area. It has over 87,000 miles of rural highways, nearly 4 per cent of the total in the United States, or about twice the average number of miles of rural highway for each square mile of territory.

Its yearly crops before the war were worth over $141,000,000, or 2½ per cent of the crops of the country, and its manufactured products were over $2,500,000,000 a year, or nearly 13 per cent of the manufactured products of the country.

IMPROVED HIGHWAY MILEAGE.

The New England States, especially Connecticut and Massachusetts, were among the very first to adopt a State highway or State aid system. As a matter of fact, I believe New Jersey was the only other State to begin a comprehensive State or State-aid system of improved highways 25 or 26 years ago. The results accomplished in New England show clearly the advantage of such a system.

I am using the figures published by the United States Office of Public Roads to January 1, 1917, allowing for recent improvements. Out of about 75,000 miles of improved rural highways in the United States maintained under the State or State-aid system, 11,589 miles, or 15½ per cent, were in New England. Nearly one-half of these highways were in Connecticut and Massachusetts.

There were in the United States about 69,000 miles of highway which had been constructed under the State or State-aid system, and of these more than 9,000 miles, or 13 per cent, were in New England. (I believe the figures published by the department are only rural highways and exclude improved highways and streets in cities, towns, and villages.)

It is stated that there are 287,000 miles of rural highway that have been surfaced in the United States. More than 40,000 miles of these, or about 14 per cent, are in New England. If city, town, and village streets were added, the mileage would be much larger.

WILLIAM D. SOHIER

In 1916 we found that there were over 23,000 miles of highway in Massachusetts, and that about one-half of them were improved roads or streets, to wit, roads that had been graded, drained, and had material brought in to build the road. Most of these were constructed with a gravel surface or of some stronger material.

Since those statistics were made in my home State, Massachusetts, the mileage of road improved as State highway or State-aid roads has increased from 1,100 miles credited to us by the Government, to over 2,300 miles of improved highway that is maintained. I believe some of our neighboring States have done as well or even better.

The conditions are quite different in the six New England States. The three northern States—Maine, New Hampshire, and Vermont—are, to a great extent, agricultural and lumbering States, although they have also great attractions for summer residents and tourists. With the exception of relatively a few miles on the main trunk lines, their highways do not have any large bulk of heavy traffic.

ROADS CARRYING HEAVY TRAFFIC.

The other three States, Massachusetts, Rhode Island and Connecticut, on the other hand—while there is considerable farming in Massachusetts and Connecticut, and quite a little intensive farming in Rhode Island—are in the main manufacturing States, and are very thickly populated, their roads carrying very heavy traffic. The highways in these States are also used on through routes to the seaboard from the interior, and have had to carry a considerable amount of trucking for the Army.

These last three States can afford to spend very much more per mile of road, both in construction and maintenance, than the northern States. Most of the improved highways in the three northern States are, and must be, constructed of local materials, being very largely gravel roads or improved dirt roads.

The main trunk lines in Massachusetts, Rhode Island, and Connecticut have been very largely constructed during the last 20 to 25 years, starting originally with some gravel and a great many miles of waterbound macadam work, continuing bituminous macadam and concrete.

The traffic on these roads has very largely increased year by year on account of the manufacturing and especially because of the war activities during the last year. The roads have had to be considerably widened; many of them have had to be resurfaced. It has been found everywhere where there was heavy truck traffic that a 14 to 16 foot width of hardened surface was insufficient on main highways; that at least 18 feet was necessary or it sheared oft on the edges.

It has been found that waterbound macadam roads or roads with surface treatments will not, unless upon unusually good soil or foundations, withstand heavy trucks and truck traffic, especially when the frost is coming out of the ground in the spring.

THE ROAD WORK DONE IN 1918.

I think every one of the New England States this year has confined its work to its most important main through lines. They have cut down construction to a minimum, and the little construction that has been done has been on the main through lines.

They have also, as far as possible, when funds would permit, reconstructed or resurfaced the worst and weakest portions of these main trunk lines, attempting whenever possible to build a road that would be sufficient to stand up under the modern increased traffic.

In common, no doubt, with all the States, we have been handicapped by a shortage of labor and materials, especially bituminous materials, shortage of railroad cars and transportation, and we have had to pay very large and constantly increasing prices for labor, for teams, for materials, and for everything that went into the work.

In Massachusetts we have had something over 80 of our engineers, foremen, etc., go to the war. Of course the same thing has happend to the laborers and patrol men, which meant very much harder work on the part of the few men who remained, especially the division engineers and their assistants who had charge of the field work, and perhaps more particularly those who had charge of the patrol gangs and maintenance work.

The cost of road work in New England has increased substantially from 50 to 100 per cent, this being an estimate of increased cost of construction or reconstruction including materials, and probably very nearly as large an increase of cost of maintenance, especially of the old waterbound macadam roads, of which there are very many miles in Massachusetts, Rhode Island, and Connecticut, which it was impossible to reconstruct and which were very much damaged by truck traffic, especially when the frost was coming out of the ground.

INEFFICIENCY OF LABOR.

Experienced engineers and contractors with whom I have talked, and I think the commissioners in the other States, agree that they think that there have been two main causes of the increased cost of the work; first, increased wages, and second, and at least equally important, the inefficiency and instability of the labor when we did secure it.

While the cost of labor, teams, materials, etc., has been constantly increasing year by year for some time, not only because of an increase in the amounts paid but also because of shorter hours of labor in many States, the work in 1917 and 1918 has been very much more expensive than in 1916 because of war conditions.

The cost of maintenance in all the New Englan States has practically increased from 50 to 75 pe cent unless possibly in Connecticut where ther was a considerable increase in 1917, so that in 191 the cost increased only 20 per cent on labor items.

In most places the cost of construction or reconstruction has increased from 75 to 100 per cent o even more. In a few of the country districts th cost of the work has not increased so much becaus local labor and teams were used when they wer not urgently needed on the farms. Also, th patrol men and men employed on the maintenanc of the main roads are more permanent, as the generally are men who live in the locality.

Whereas in 1916 laborers were paid $1.75 to $ for an 8-hour day, in Massachusetts, in 1918 we ha to pay on the average, except for local men, from $3.20 to $4 for an 8-hour day. Teams which i 1916 cost from $4.50 to $5.50 a day cost in 191 from $6 to even $8 per day. The cost of material and freight also increased from 50 to over 100 pe cent from 1916 to 1918.

INCREASED COSTS IN TWO YEARS.

This is well shown by two sections of State highway that were resurfaced in two towns, one section i each town, in 1916, and the second in 1918. Both were contracts advertised and let, the construction being the same each year.

Herewith are costs for surfacing work let on adjoining sections of State road in Lunenburg and Phillipston for 1916 and 1918.

Lunenburg.

	1916	1918
Excavation	$0.60	$1.30
Trap rock	2.70	3.60
Bitumen, furnished and applied	.15	.24
Stone fill	1.00	2.[illegible]
Sand filler	1.35	1.60
Stone screened	1.40	2.75

Using the quantities in the 1918 surfacing the increase over cost for 1916 was 57 per cent.

Phillipston.

	1916	1918
Excavation	$0.80	$1.50
Borrow	1.25	1.75
Trap rock	3.50	4.30
Bitumen, furnished and applied	.17	.25
Sand filler	1.25	2.00

Increased cost of 1918 contract for above items was 33 per cent above cost if 1916 prices are used.

The cost of maintaining the older waterbound macadam or gravel roads on the main lines is well shown by the following table:

Town.	1916	1918
Athol (west)	$175.05	$504.52
Bernardston (east)	485.89	819.14
Erving (east)	462.06	1,477.56
Fitchburg (west)	130.62	202.29
Gardner (west)	487.80	1,188.68
Shelburne (village)	225.95	501.98
Templeton (east)	330.19	882.18
Winchendon (Maple Street)	364.35	872.68

These roads have all been maintained by surface treatments of asphaltic oil and kept constantly patched.

A very considerable item in the increased cost is due to the increasing use of motor trucks and especially the heavy motor trucks carrying 3 tons or more on solid tires.

In Massachusetts, Rhode Island, and New Hampshire a good many miles of improved road suffered quite severely, especially in the early part of the season, because it was impossible to obtain the bituminous materials, or get their requests for permits granted during the first three or four months of the season. Lately the situation has much improved.

WEIGHT AND SPEED OF TRUCKS.

I believe one of the most important topics to be considered at this convention should be the devising of some sensible, stringent, and uniform regulation governing weight, speed, and width of motor trucks that are to use our roads; that excessively heavy loads must be absolutely prohibited or prevented from using any of our highways or bridges when the highways or bridges have not as yet been made adequate to sustain such vehicles and loads.

Road building is a constant evolution, because no sooner is the improved road built to carry a vehicle of a certain weight and size than the builder of the vehicles tries to increase both the weight and size.

I personally believe that there should be a very stringent regulation and limitation on both the weight and speed, as well as the width of the vehicles that are allowed to use our highways and bridges. I believe also that if heavy trucks are to be allowed to use the highways there should be some provision for routing them so they can not wander at will over out little country roads, destroying bridges and culverts and tearing up roads that are now adequate for all local traffic.

If heavy trucks are to use the highways they should be confined to the main lines only, and only such weights should be permitted as can safely use the highways and bridges that have been constructed. Otherwise we shall have a great many miles of road that it has taken many years to improve and build up destroyed, many bridges broken down, and our main roads will be put out of commission so that no one can use them for long periods of time.

FUTURE HIGHWAY TRAFFIC.

What will our highways have to carry in the near future?

We can only judge of this by our past experience. That the motor traffic will increase is sure. This is well shown by the following table, showing the increase, in Massachusetts, in motor vehicles in six years, and in the number of operators and the fees collected:

	1912	1915	1918	Per cent increase 6 years.
Automobiles and trucks	50,132	102,633	191,019	280
Motor cycles	5,034	9,520	12,708	150
Operators and chauffers	65,600	133,700	225,272	240
Motor-vehicle fees	$616,236	$1,235,723	$2,159,257	250

There are over three times as many automobiles and trucks registered as there were six years ago, over three times as many operators, and the fees collected are three times as large.

All these fees are spent in maintaining and improving our main highways. In fact, last year, we practically maintained all our main highways with the money collected from this source.

How the truck traffic has increased is shown by the following table:

	1915	1916	1917	1918	Per cent increase 3 years.
Trucks	12,053	18,194	25,505	32,676	171
Automobiles	90,580	118,615	145,801	158,343	75
Motor cycles	9,520	10,713	10,956	12,708	33

The number of trucks and commercial vehicles registered has increased from over 12,000 in 1915, to over 32,000 in 1918—more than 2½ times as many trucks as there were three years ago.

DAILY TRAFFIC ON MAIN ROADS.

The change that has taken place in traffic is clearly shown by the following table. This is made up from traffic counts taken every three years from 1909 to this year. An actual count is made for 14 hours a day for 7 days in August and 7 days in October. The table which follows shows the average number of vehicles that are using our main highways, and is based upon the average count in each of these years at 44 stations on main lines.

44 stations.	1909	1912	1915	1918	Per cent increase 9 years.
Light horse...	91	[illegible]	40	24	[illegible]
Heavy horse..	88	88	72	43	[1] 51
Total horse	179	[illegible]	112	[illegible]	[illegible]
Automobiles and light truck ...	131	[illegible]	555	[illegible]	[illegible]
Heavy truck.		17	[illegible]	75	[illegible]
Total motors..	131	296	[illegible]	[illegible]	[illegible]
Total vehicles..	310	[illegible]	712	[illegible]	243

[1] Decrease.

[2] [illegible] years.

This clearly shows what is happening on our roads.

In 1909 there were practically no trucks using our roads. In 1912 there was an average of 17. In 1915 there were 45, and in 1918, 75, using the roads at the same stations. In other words, the number of trucks using the main highway has increased 4½ times in 6 years.

The change in the traffic is perhaps even more graphically shown by the following table of percentages:

PER CENT OF TOTAL TRAFFIC.

	1909	1912	1915	1918
Light horse...	29	15	[illegible]	2
Heavy horse....	28	19	10	4
Total horse	57	34	15½	6
Trucks.		4	6½	7
Motors..	[illegible]	62	78	87

It is astonishing but true that while horse-drawn vehicles constituted 57 per cent of all the traffic on our main highways in 1909, in 1918 there was only 6 per cent of the traffic horse-drawn vehicles; and motor vehicles, which were only 43 per cent of our traffic in 1909, were 94 per cent in 1918. We must not forget that the total traffic using the roads has increased over three fold.

While the horse-drawn vehicles are to-day only 6 per cent of the total traffic using our highways, the heavy motor trucks, to wit, over 1 ton, not on pneumatic tires, have already become 7 per cent of the total traffic. Perhaps even more significant is the change in the last 3 years. During that short period of time both the automobile traffic and the motor truck traffic has increased 66 per cent, or an increase of about 22 per cent a year.

While the average traffic shown in the foregoing tables gives a fair indication of what is happening all over the State, there are a number of main highways that are tributary to our larger cities and manufacturing plants and the seaboard, where the traffic, and especially the truck traffic, has increased very much more rapidly. This is shown by the accompanying comparison of the traffic at 15 points on main trunk lines:

DAILY TRAFFIC ON MAIN ROADS.

	Year.	Total horse.	Automobiles.	Trucks.	Total vehicles.
Brookfield	1915	36	607	19	662
	1918	56	1,119	83	1,258
Shrewsbury	1915	142	922	39	1,103
	1918	66	1,575	112	1,753
West Boylston	1915	118	529	22	669
	1918	65	1,195	85	1,345
Deerfield	1915	234	281	25	540
	1918	344	873	64	1,281
Westwood	1915	76	967	49	1,092
	1918	28	1,379	179	1,586
Concord-Acton	1915	48	653	19	720
	1918	38	1,484	238	1,760
Concord-Harvard	1915	57	238	16	311
	1918	55	523	107	685
Fall River	1915	326	763	61	1,150
	1918	508	1,840	403	2,751
Longmeadow	1915	115	1,150	83	1,348
	1918	54	2,062	135	2,251
Salem	1915	144	1,113	181	1,438
	1918	51	2,636	224	2,911
Revere traffic and Saugus	1915	301	....	212	....
	1918	215	....	398	....

Brookfield, the first, is on the main line between Worcester and Springfield, carried a certain amount of Army supply traffic.

Shrewsbury is on the mian line between Worcester and Boston.

West Boyslton is on the main line between Worcester and Fitchburg and doubtless had some traffic tributary to the Army cantonment at Camp Devens.

Deerfield is on the main line in the Connecticut Valley, between Greenfield and Vermont points and Springfield and Connecticut points.

Westwood is on the main line between Boston and Providence, about 12 miles out of the city of Boston.

The counts on two different roads in Concord show the amount of traffic that was put onto the roads by the building of an Army cantonment. Camp Devens is located at Ayer, about 36 miles out of Boston, and the change in the traffic on these two roads is undoubtedly due to the presence of that cantonment. The two roads together had 35 trucks in 1915, but three years later, in 1918, they had 345, or over ten times as many. The total number of automobiles was less than 900 in 1915 and over 2,000 in 1918, three years later.

The count in Fall River is on the main road running westerly out of that city and covers traffic going to several places, the main traffic going north to Taunton and west to Providence.

Longmeadow is situated just south of Springfield, and covers the traffic going south toward Hartford and Connecticut points.

Salem is on the main line to New Hampshire points, and also to the North Shore.

The last count, Revere and Saugus, shows traffic on two roads, one of them being recently opened, and the counts merged in order to show the increase in truck traffic going to the city of Lynn, which is a large manufacturing city situated about 11 miles from Boston. Here the number of trucks had increased from 176 a day to 398 a day in three years.

These figures show very clearly what is going to happen in the immediate neighborhood of our big cities on the main trunk lines connecting large industrial centers with each other.

Undoubtedly a good deal of this traffic was due to war conditions, the roads being used by Army trucks and by more than the usual number of commercial vehicles because of the congestion on the railroads.

On the other hand, the traffic counts also show that this increase in heavy truck traffic is two or three times greater on main through lines connecting important cities together that are within 40 miles of each other, and that the truck traffic there has increased much more than it has on the through routes in the country districts.

It is perfectly clear, however, that the highways of the future will have to be constructed wide enough and strong enough to carry with reasonable safety the constantly increasing number of vehicles that will go over them; that a highway will have to be provided that can stand up under the constantly increasing traffic in motor trucks.

This means that the old waterbound macadam roads which were built 5 or 6 inches thick on ordinary soil will not last or be economical, even with a surface treatment, if they are on a main route that has to carry an average of 50 to 100 heavy motor trucks a day.

A well-drained foundation will be necessary even for bituminous macadam, unless the subsoil is porous and well-drained sand or gravel, and even then it may be found more economical, to build a more expensive and stronger pavement on main routes that have a large amount of heavy truck traffic.

The Present Situation and How We are Meeting It in the Middle West

JON A. HAZLEWOOD, Chairman Wisconsin Highway Commission.

JUDGING from reports from the various States in the Central West, those engaged in the road game are meeting the present situation patiently and courageously. The financing of more road work than could possibly be done with the labor and transportation facilities seems to have been true in each section.

1918 COMPARED WITH OTHER YEARS.

Michigan reports that 793 miles were accepted and rewards paid, while in 1917 1,053 miles of road were constructed and State rewards claimed. This makes a loss of about 25 per cent. Kentucky reports the construction of 1918 was about 25 per cent of that of 1917. In Iowa the actual unit of road and bridge work accomplished in 1918 will be less than 50 per cent of the construction in 1917.

Minnesota states that the construction in 1918 compares favorably with previous years. While only three-fourths of the average annual mileage of previous years was completed the work was of more substantial character. Illinois reports that 1918, compared with previous years, shows that the State aid work constructed amounted to about one-twentieth. The total road expenditures by townships was curtailed about 50 per cent, due largely to the inability of towns to secure oils for earth roads.

North Dakota operated for the first year under a State highway commission, but notwithstanding it has been able to supervise the expenditure of almost $2,500,000 on its highways. Shortage of labor on account of the demands made for harvesting and thrashing forced the road work to come to a standstill about the 1st of August. South Dakota reports that the war has very greatly handicapped the work in that State.

Kansas reports their highway commission was in the course of organization in 1917, and during that year there was practically no work performed. Work in 1918 was very limited in scope and character. Construction for 1918 has been restricted in Nebraska on account of war conditions. About 215 miles of road however were put under contract involving an expenditure of $468,400. This is the first year Nebraska has given aid to its public highways. In Wisconsin it is estimated that the season's work in 1918 will be only 60 per cent of the work carried on during the previous year.

ARRANGEMENTS MADE FOR YEAR'S WORK.

Michigan reports that no special arrangements were made in 1918 over other years except that they had to pay more for work and work harder in order to construct the mileage undertaken. New labor-saving devices came in to help out in the situation to a marked degree.

Kentucky reports that they were unable to make any special arrangements to carry on their work, but confined it to counties where local material was available. Convict labor was used to a limited extent. Minnesota reports they had no special arrangements for handling the work of this year different than in any other year.

Illinois reports that the supply of local material was so small as to make it impossible for them to change types of road construction; in fact, the lack of local material was chiefly responsible for the almost complete shut down of road construction in the State. The only important change made in Illinois construction methods was involved in Federal-aid road work. Five labor gangs on concrete roads were used.

North Dakota and South Dakota also report that they made no special arrangements for construction work in 1918. Kansas states that no special arrangements were made for 1918 construction work. A few contracts were let and carried out in the usual manner, and those upon which bids could not be obtained were abandoned. In Nebraska no special arrangements were made for 1918 work, except that the use of machinery was encouraged.

In Wisconsin, owing to the restrictions which were enforced, the only work which could be attempted on anything but the smallest scale was grading and surfacing operations, involving the use of local materials, where no rail shipments were required. Only about one-third of the normal bridge work was done.

THE COST IN 1918 AND RECENT YEARS.

Michigan reports the cost of work, compared with recent years, as 25 per cent higher, and Kentucky about 25 per cent higher than in recent years. Iowa states that the increase in the cost of bridge work was at least 50 per cent over that of 1916. The increased cost of grading on account of labor amounted to about 75 per cent over that of 1917, and the increased cost of surfacing, including paving, was 50 per cent over that of previous years. Minnesota reports the cost approximately 30 per cent higher than in 1917.

Illinois reports that the State-aid work which was completed this year was under previous contracts and the old prices held, so that they have no means of knowing the cost of the work compared to other years. The cost of force account work as yet has not been summarized accurately, but approximately it will run about 30 per cent over prewar prices. In North Dakota the work may be said to average about 40 per cent to 50 per cent higher than the cost of previous years, and in South Dakota to almost 75 per cent more.

Kansas states they cannot compare the cost of 1918 work with recent years, as this is the first year of operation under their highway commission. In Nebraska the cost of the work done in 1918 has been approximately one-third higher than similar work done in recent years. In Wisconsin, the cost of labor advanced more in proportion than the cost of material. The increase was 15 per cent to 25 per cent over 1917, the higher percentages applying to work where the labor item was the largest.

CHANGES IN ENGINEERING FORCES.

Michigan states that the department has suffered greatly in personnel in the last two years due to men entering the service. Thirty-nine men from the engineering department out of not to exceed 100 men at any time in the history of the activity, entered the military service. Reports state that it has been necessary to use girls in the drafting room and to resort to a good many makeshifts that heretofore were thought impossible.

Kentucky reports that no changes in engineering organization were made except that the legislature passed an act requiring the State department to make surveys and plans for all road construction. Heretofore the surveys and plans had been made by the counties, subject to approval by the State officials. The act necessitated the employment of field engineers and assistants.

Iowa states that it was absolutely impossible for them to obtain a sufficient number of men to handle the drafting and engineering work, so they substituted women for men. The women employed were trained in this work by the highway commission. A woman who was a graduate engineer was placed in charge of the draftswomen. The Iowa commission was well pleased with the results obtained.

Resident engineers in Minnesota were required to handle considerable of the instrument and detail work, which is otherwise taken care of by the assistant State engineers.

Illinois reports that they employed in 1917, 125 engineers. Since war was declared about 87 engineers employed by the department either enlisted or were drafted. The curtailment of the work undertaken made it unnecessary to replace many of these men. Previous to the war they had seven district engineers. Seven districts were combined this year into five districts.

North Dakota states that as this was the first year of their commission they had not fully or definitely established an organization to require any changes to meet the conditions encountered. They have had, however, to assemble the work in several counties, so it could be taken care of by one engineer, and in the case of force account work have had to make special assignments of engineers to look after particular parts of certain projects. In South Dakota the work has been handled in 1918 very much as in previous years, except with a more limited number of employees.

Kansas states that no material changes in their engineering department took place in 1918, the only notable feature being that their State engineer, Mr. Gerhart, entered military service, which somewhat affected the personnel of their organization. No changes were made in the engineering arrangements of Nebraska during 1918. In Wisconsin the engineering force was approximately one-half of what it was at its maximum in 1917. The greatest portion of the force stayed through the active part of the season, but in all 46 men left the department to enter the United States Army service. Some of these men were replaced, but rarely with men of the same caliber. The surveys and plans, however, have been held up to the old standard with the exception of a very few sample grading jobs, which have been allowed to be built with only field staking out.

CONSTRUCTION PLANS FOR 1919.

Michigan reports that plans for 1919 call for greater mileage than has ever been heretofore undertaken. The last legislature passed a road assessment tax act, which makes it possible to start road work on petition and pay part of the cost by special assessment on the district which is to be especially benefited. The department has more than 1,000 miles of these petitions which can be acted on as soon as labor conditions warrant. These, taken together with the federal aid roads which will be built by the State and the 1,000 miles of road which will be built by townships and counties of the State, will make possible and probable the largest road program ever carried out in the State. Kentucky reports that the department plans for a largely increased program of construction and maintenance work during 1919.

Iowa is not contemplating any greatly increased program of road work for 1919. The hope is to be able to carry forward to successful construction the federal aid projects upon which they were unable to obtain bids this year.

Minnesota states the plans for 1919 have not been perfected, but they ascertain that there will be approximately $4,000,000 worth of work done on the State road system next year, principally grading and gravel surfacing.

Illinois contemplates as large a road construction program as it is possible to put under way with the engineers they are able to obtain.

North Dakota has a large road program to carry out next year. One of the principal lines of work of the highway department is the Federal aid work, which involves the construction of about $600,000 worth of work annually for a period of four years. The engineers' problem is particularly difficult, due to the fact that the cost of the roads is expected to be not much more than $1,500 a mile. South Dakota has eight projects which it contemplates building in 1919.

Kansas states it has its Federal aid projects well in command. It expects to carry forward a general good roads program for 1919. Nebraska's plans for 1919 contemplate the improvement of 752 miles of road with State and Federal aid amounting to $1,660,000, besides the building of many county and State aid bridges, which will bring the total expenditures to $2,000,000.

Wisconsin expects to carry forward a maintenance program of road work in 1919, in addition to a very full program of road construction on Federal aid projects and State aid work. County boards in the State have made very liberal appropriations for road construction and road maintenance, so that the program in Wisconsin will certainly be a big one for next year, very probably much the largest in her history.

PUBLIC SUPPORTS ROAD WORK.

In Michigan public sentiment favorable to road improvement is continually increasing. The highway commissioner states that propaganda is hardly necessary in Michigan in order to stimulate the work. Kentucky states that public sentiment is very favorable toward road construction, and is especially favorable to road maintenance.

Iowa reports that the sentiment for road work was never stronger. The increase of motor vehicles of all kinds has been very marked and in localities the operation of motor truck routes on a regular schedule has been established. Minnesota reports public sentiment strongly supporting all feasible and practical road programs.

Illinois has evidenced its interest in the road movement by voting a bond issue of about $60,000,000 by a majority of approximately 200,000. The bond issue law calls for the construction of 4,800 miles. People there have been given to understand that $66,000,000 would be made available by the bond issue and Federal aid combined, or about $13,800 per mile.

North Dakota reports that the sentiment for building and maintaining better roads and developing the State highway and better county systems of roads is all that could be expected. South Dakota reports that public sentiment is good and the people are looking forward to better highways and are willing to meet it with proper taxation.

Kansas public sentiment is the very best. Reports state that Kansas has been lacking pride in this important work until the beginning of 1917, but since that time the State has experienced a decided change in sentiment and the road program is sure to go forward by leaps and bounds. The public sentiment in Nebraska is becoming enthusiastic as the people become educated to the value of good roads. In Wisconsin public sentiment for road construction and maintenance is all that could be hoped.

PROPOSED STATE LEGISLATION.

Michigan looks forward to the State building and maintaining the trunk lines, and does not look for any material change except the strengthening of the trunk-line legislation.

Kentucky reports that the legislature does not meet until the winter of 1920, consequently there is no legislative program developed for next year.

Iowa contemplates the changing of the proposed plans for road and bridge work. The State reports that the most necessary legislation relates entirely to the financing of road construction and maintenance, and legislation along this line is expected during the coming winter.

Minnesota wishes to bring about legislation providing a more favorable condition for a bond issue for hard surfacing of highways along the lines of the Illinois plan. Much effort is being put forth to bring about a more hearty support in favor of a more liberal plan of financing road construction and maintenance.

In Illinois a considerable amount of legislation is contemplated to correct minor defects in the present road law, but none of this might be considered of special interest. Efforts will be made to pass legislation for the regulation of highway traffic, with especial reference to maximum loads.

North Dakota reports that the law under which the commission is operating is ambiguous and indefinite in many respects, but has nevertheless been found to be a workable law. If no road organization interests itself in highway legislation for the coming session of the legislature there is some reason to believe that the department will attempt to make certain recommendations for the improvement of conditions over the present law, providing for more ample funds. Much study and attention must be given to legislation in the State in order to provide conditions necessary for the proper maintenance and construction of their system of roads.

South Dakota is looking forward to better highway legislation, favorable to providing more funds for road work. No definite plan has thus far, however, been worked out.

Kansas reports that there will be no legislation which is of especial interest. The present law does not permit State aid on account of constitutional provisions. The State expects to get an amendment passed by the legislature and submit it at an election in order to permit State aid There may possibly be some efforts to change the method of distributing automobile funds. Nebraska's legislative program has not been formulated.

Wisconsin states that there is not expected to be any radical change in highway laws of the State at the coming session of the legislature. There may be some additions made to the State trunk highway system. It appears that there is some inequity in the distribution of maintenance funds which it is probable will be removed.

CONDITIONS MET IN 1918.

In the Central West construction in 1918 has been between 25 per cent and 50 per cent below 1917; almost every State highway department has been forced to make special arrangements to handle the surveying, drafting, and engineering work on account of the large number that have been called away from service. The cost of work done was about 40 per cent higher than in 1917, owing to the increased prices of materials and labor. Some of the State departments were obliged to throw back on the counties and divisions a part of the surveying, drafting, and engineering work formerly done by the State. In many cases women were trained and employed for drafting.

CONSTRUCTION TO BE INCREASED.

The plans for 1919 work in most of the States were not much more comprehensive than work done this year at the time reports were made. Now that the war is over it is quite likely that the scope and character of the work will be enlarged upon, since contracts might be more numerous and labor and materials more available. Now that the ban is raised, and a policy of governmental encouragement substituted, we can look forward to highway work going along by leaps and bounds. Public sentiment for road work could not be better anywhere than it is in the Central West; proposed legislation in the States seems to be along the line of speeding up the construction of hard-surfaced roads through bond issues, and for establishing a more complete and scientific system of road maintenance.

ROAD BONDS IN MISSOURI.

There is a movement in Missouri for submission to the people of the question of a road bond issue amounting to $50,000,000. The proposition is to use motor-license receipts for paying the principal and interest on the bonds. Outside of this bond issue the legislature this winter is likely to consider important road legislation in order to hasten construction of a State system as outlined by the State Highway Department, which was created in 1917. Sentiment in the State in favor of better roads is steadily growing.

The Present Situation and How We are Meeting it in the South

W. S. KELLER, Engineer Alabama State Highway Department.

W. S. KELLER

WHEN this program was prepared, it was "before the war." I am thankful with you that it is now "after the war" and I feel sure we all look forward with eagerness to the great work that will be set before us in 1919, and with renewed vigor make up for the time lost in whipping the Hun.

If I was permitted to confine my remarks to the restricted territory of Alabama, rather than the entire South, I would feel no uneasiness that what I say would be questioned. If the representatives of several Southern States do not agree with me and think I am misrepresenting their States, I warn them to keep quiet on pain of being exposed as those who ignore polite requests for information. As I, too, am sometimes guilty of overlooking requests, I forgive them, provided, of course, they will never let it occur again, and promise to forgive me for like omissions.

From information furnished me from other States, together with our own experience, I can partially, though poorly, give an account of the South.

REDUCED CONSTRUCTION IN 1918.

The shortage and high cost of labor, the high cost of materials and machinery and the Government restrictions on the purchase and shipment of materials have reduced construction to approximately one-third of what it was in 1915 and 1916.

The extension of aid by the Government has been a stimulus, especially in my own State, to carry on despite the handicaps. Very few contracts were awarded, for the good reason that no bids were offered. Contractors were more afraid of the uncertainty of labor than the prevailing high wages. Convict labor has made it possible for many projects to be constructed that otherwise would have been indefinitely postponed. We are much better down South than we used to be, and do not have many convicts and a well-manned convict outfit is an exception rather than the rule. No able-bodied convict now has to work out his fine, for there is always some one ready to settle for him and take a chance on getting it back in labor, and many counties have had to abandon this method of road building. The State of Georgia has, perhaps, been most fortunate, because of the fact that State convicts are worked on the roads, whereas, in the other States only county men can be so used.

If any special arrangements were made to overcome labor shortage and Government restrictions, I was ignorant of it. We have to a certain extent used labor-saving devices and machinery to advantage. We have found it hard to replace the negro and the mule.

THE INCREASE IN COST OF WORK.

The cost of work during the current year will average 50 per cent greater than in 1916 and 1917. The cost has varied greatly. Where work was in close proximity to a military camp or Government works of any kind prices were much higher than at places far removed from them. An average cost on four items in Alabama will give a clear idea of the increase:

1917:	
Earth excavation (rock excluded), per cubic yard	$0.22+
24-inch D. S. vitrified-clay pipe, per linear foot	1.82
Sand-clay surfacing within 1 mile, per cubic yard	.32½
Class A concrete, per cubic yard	15.00
1918:	
Earth excavation (rock excluded), per cubic yard	.33¾
24-inch D. S. vitrified-clay pipe, per linear foot	2.54
Sand-clay surfacing within 1 mile, per cubic yard	.50
Class A concrete, per cubic yard	20.00

One peculiar factor that has added to the cost of our work is the dislike of the average negro laborer for work when he has any money. It simply burns a hole in his pocket and he must lay off several days in every week in order to spend it, with the consequent more or less demoralization of work and the resultant increase in cost.

ENGINEERING ARRANGEMENTS.

No two States are doing their engineering work exactly alike, and to answer this question intelligently, it would necessitate a detailed statement from each State. No doubt every State contemplates advantageous legislation permitting improved engineering arrangements. I can state, however, that the South is fully awake to the value of engineering, supervision of road construction, and maintenance, and we can look forward with a degree of certainty to a time when every county will have an engineer.

SOUTH TO SPEND $15,000,000 IN 1919.

Plans for 1919: Federal aid for the Government fiscal years 1918 and 1919 for nine Southern States amounts to $4,175,583.80. A like amount form the States gives a total of $8,351,167.60. Only a fractional part of this appropriation was used during the past year. As an offset for what has been used, fully as much of the 1920 appropriation will be spent by some of the States. I think a conservative estimate of the amount that will be spent for road construction in the South from all sources will be fully $15,000,000. In making this statement, I am assuming that labor conditions will materially improve. I can also safely say that the roads that will be constructed in the future will be better roads than those built in the past.

PUBLIC SENTIMENT FAVORABLE.

With us in times past it was necessary to hold frequent meetings at which silver tongue orators, generally with a political bee in their bonnets, would expatiate at length on the great benefits to be derived from a system of good roads. In order for a county to issue bonds an extensive and sometimes expensive campaign was necessary. From one extreme we have gone to the other. It is now necessary to warn county officials from putting their counties hopelessly in debt and to such an extent that all the tax funds go to pay interest, with nothing left for maintenance.

The road sentiment in the South is good. We do need, however, to educate our people to the point where each individual will so appreciate his road that he will protect rather than abuse it. We are too prone to throw the entire responsibility for the upkeep of our highways upon road officials, while at the same time we openly violate a road law. I am sorry to say that we have not the respect for road laws that you of the North have.

I am pleased to say that the South is now thoroughly convinced of the futility of building cheap roads and bridges to sustain heavy traffic. Like the rest of the country we have had to meet conditions brought about by the rapid evolution of travel and especially the great increase in truck haulage.

The Federal road law has been a very pleasing factor in the further development of road sentiment with us.

Recent Damage to Eastern Road Systems and Problems New Conditions Developed

W. G. THOMPSON, State Highway Engineer of New Jersey.

EXCEPT as the methods employed in repairs differ with the types of pavement predominant in our respective localities, our recent road problems were, I think, quite similar.

These problems, briefly stated, were: A traffic, unprecedented as to volume and weight; shortage of labor and materials due to Governmental restrictions and operations; and uncertain rail delivery due to war priorities. We had also to reckon with winter conditions such as the Eastern States had not experienced since the blizzard of 1888. Highway officials and others responsible for the upkeep of the roads found it difficult to make headway against this combination of conditions, as generally speaking the existing highways in this country were not designed to bear the loads which passed over them between July, 1917, and July, 1918.

Until the advent of the motor vehicle macadam roads were considered suitable for rural and interurban traffic in the Eastern States. With the coming of the automobile it was soon evident that such pavement would not suffice without excessive maintenance charges, but most States and smaller communities lacked the courage, or perhaps we should say foresight, to adopt programs providing for more durable pavements, hence we found ourselves faced with the problem of maintaining thousands of miles of macadam pavement utterly unsuited to a traffic growing by leaps and bounds as to volume, weight, and speed.

MACADAM FORMERLY EFFICIENT.

For more than 30 years macadam construction was the best known and quite satisfactory for the traffic using it. The transition from horse-drawn to motor vehicles was so rapid and the destruction of pavements due to high speed and suction of pneumatic rubber tires was so widespread that many communities were and still are unable to adjust themselves financially to the new needs. When motor cars first appeared none but the wealthy could own and operate them, and as they were looked upon as a favored few the ordinary taxpayer did not look favorably upon spending large sums to build smooth durable country highways solely for the pleasure of city people. When the price of automobiles became so low that ordinary citizens could own them, and owners increased to the thousands and millions, people began to take an interest in highways and Mr. Ordinary Citizen, who formerly voted in town meeting against the appropriation of $600 to repair all the roads in the township, began to ask: "What is the matter with these cussed highway officials?" The disgraceful part of the matter is that most of said cussing was done on Sunday afternoons when he took the family to ride.

I think it will be conceded that there was no widespread interest or concerted action for good interurban and country highways until the farmers and people of ordinary means began to buy automobiles, though the use of our roads for freight transport made necessary by munitions business incidental to the opening of the European war in 1914 soon made it evident that then existing types of pavement would not stand the strain.

FOUNDATIONS AND DRAINAGE FAIL.

The entry of our country into the European war and the railroad congestion of last winter subjected our roads to the supreme test, under which many of them failed most lamentably, although every effort was made to keep the through routes passable. Most of our failures were due to insufficient and unstable foundation and inadequate drainage, which lack of drainage in conjunction with the expansive effect of frost in many places simply turned the roads upside down. Added to this, the incessant passage of heavily loaded trucks turned the saturated sub-base into a quagmire. A consequence of this was a loosening of the stones in the underside of the pavement, resulting in such a disintegration of the structure that in many cases the rear wheels broke through the crust and it was necessary to jack up the vehicle and place planks under the wheels to extricate it.

These conditions applied not only to the water bound and bituminous macadam pavements, but to the asphaltic concrete pavements laid on macadam or broken stone foundations as well. We had many cases where expensive bituminous pavements laid on macadam bases of insufficient thickness, and inadequately drained, blew up or broke through under the heavy loads and constant traffic. When I say constant traffic I mean a continuous procession of trucks in both directions, besides the thousands of passenger and lighter cars. As an instance of the density of passenger-car traffic to and through the New Jersey coast resorts, a census was taken on a Sunday afternoon last summer at a bridge where all traffic along the shore must converge to cross a stream. Between 2.30 and 6.30 p. m. more than 5,000 cars passed a given point. It is easily realized that the problem of providing improvements adequate to sustain such a traffic is a serious one.

I believe I am safe in saying that highways in the East suffered greater damage during 1917 and 1918 than during the preceding three years. Neglect or inability to remove snow caused the ruin of miles of eastern pavements last winter. Heavy trucks wallowed through and finally broke a path, which eventually wore down to the pavement. Other vehicles followed the same track, which except for certain stretches was used for several weeks; thus the entire traffic was confined to a few inches of width in each wheel track instead of being equally distributed over the entire surface. This naturally resulted in deep ruts which were difficult, and in many cases, impossible to repair properly.

HEAVY SKID CHAINS DO DAMAGE.

Another destructive factor was the heavy skid chain used by the trucks. Many of these had links one-fourth inch thick and were so spaced that there were but three wraps to the wheel; therefore, instead of action resulting from the lighter chains on passenger cars where the chains are about 6 inches apart, there would be the impact and grind of these heavy chains for each one-third revolution of the wheel. No pavement could withstand such a pounding and and grinding. The man who will invent a nonskid device for heavy trucks which will reduce the destructive effect of the present chains will earn the undying gratitude of highway officials. I believe it will be necessary to forbid the use of such heavy chains, as it is impossible to build pavements to withstand their action.

This should not be taken as a brief against the widespread use of motor trucks, as I believe in the future of the motor truck, and that it will be an important factor in reducing the cost of living, particularly when roads suitable for trucks the year round are built into every farming community in this country.

The possibilities for the future of highway transportation are unlimited, but the possibilities of the highways are limited, that is, there must be a limit to the weight, tire width, and speed of vehicles using the highways, as the destruction of the past year bears evidence. If an arbitrary limit as to weight is not adopted, the race between the trucks and the highways will be a merry-go-round with the trucks always a little ahead.

HEAVY CONCRETE PAVEMENTS.

Our effort in New Jersey to lower maintenance costs and provide foundations to carry the loads resulted in the laying of concrete pavements 8 inches thick at the sides and 10½ inches thick at the center on our main through routes. It remains to be seen whether this thickness will suffice, as its adoption was purely arbitrary, and with the hope that it would prove a solution of our difficulty.

As an indication of the difficulties encountered in maintaining pavements during the past year, and of the increase in traffic volume, our traffic census on one main route shows an increase of more than 300 per cent over that of early months of 1917. Mr. Breed, of New York, reports an increase of truck tonnage varying from 50 to 400 per cent and an average increase of 150 per cent over that of 1916. Similar increases are noted in Pennsylvania, Delaware, Maryland, and the seaboard states of New England. It should be understood that these heavy increases are on the main or interstate routes, especially in Connecticut, New York, New Jersey, and Pennsylvania.

It is easy to imagine the difficulty of maintaining or rebuilding main highways under such traffic conditions. In localities where suitable detours were not available traffic was carried on the shoulders or on improvised passage ways over the roads where repairs were in progress, though at additional expense.

Where detours were available they were generally secondary or township roads built for the ordinary farm traffic, and naturally went to pieces under the pounding of heavily loaded trucks. This damage to secondary roads amounted to hundreds of thousands of dollars, and should be borne in mind by shippers and truck owners generally. Unusual efforts were uncomplainingly made to keep the trucks moving as a patriotic duty during the war period. Mr. Edward R. Viets, of the Service Recorder Co., of Cleveland, states that motor trucks increased from 60,000 in 1912, to 600,000 in 1918. These 600,000 are only a nucleus around which will be built a real fleet of trucks.

SATISFACTORY ROADS WILL COME.

The highway authorities of this country are awakening to their responsibilities and will build, as rapidly as possible, pavements capable of sustaining the traffic. It must be realized, however, by all truck users, that up to the present there has been no attempt to coordinate, so to speak, the needs of truck users and manufacturers with the means at the command of highways officials. As a consequence motor-vehicle development has far outstripped highway ability to carry it.

Need for Engineers for Highway Work and How Qualified Ones Will be Found

JOHN H. MULLEN, Deputy Commissioner of Highways, Minnesota.

THE subject "Engineers for highway work" was intended to cover a discussion of means for taking care of engineering on road work under war conditions, as practically all of the larger highway engineering organizations have been greatly depleted in the past two years. This deficiency had in many cases forced the closing down or abandonment of projects which could otherwise have proceeded, and particularly in the Middle West, where large construction forces and considerable machinery unsuited for other work was not made use of for the reason that engineers were not available for supervision.

This was an engineers' war and to the engineer must be given considerable credit for the remarkable success of our forces. It was to the engineer that our Government appealed for management of the cantonment construction, for the building of docks, railways, and the organization of transportation facilities, and when the great drive opened, it was the engineer who was in the advance, removing obstructions, building bridges, highways, and railroads, and keeping open the lines of communication, so that a continuous supply of munitions, food, and reinforcements was available when needed to support the advancing armies.

WORTH OF ENGINEER SHOWN.

Truly the engineer has demonstrated his worth in this emergency and it is a blessing to humanity that such men were available. It was the duty of those not so fortunate as to have directly participated in the war to adjust themselves to war conditions, assume some of the burden for those overseas, and endeavor to carry on the work in such a manner that the returning engineers would find their interests protected and the engineers who were obliged to stay at home doing their share in maintaining the progress and efficiency of the country were given proper recognition. That is what we were to discuss, but fortunately the war has ended, and now our problem seems even greater. The country evidently has become aroused to the need for highway improvement and is willing to spend millions of dollars for that purpose, provided there is assurance that the work will be properly handled. The public, however, does not know how this should be done, and has but a very hazy idea of the need for scientific organization and expert supervision of highway improvement.

The engineer's work in France and the progress already made in this country has, to a certain degree, opened the eyes of the public in this respect, but there is little known of the careful investigations, the close study, the hard work, and the infinite amount of detail attendant upon the successful prosecution of highway improvement. In the public mind, satisfactory results are generally credited to the contractors or superintendents of the work, who do not consider it unethical to advertise. This matter of publicity is very important and the people should be well informed on the management of highway affairs so that the engineers will be given due credit for their work.

A GREAT FIELD FOR ENGINEERS.

Highway administration offers a great field for engineers, but which will not be developed unless it is made possible to pay adequately for engineering services. This has not generally been done. Many States have worked up very efficient organizations and have been obliged to maintain them at a low expense on account of lack of funds. Some of these departments are held together through interest in the work and loyalty to the service, but this is a practical age, and if the proper kind of men are to be employed, if initiative is to be encouraged and efficiency promoted there must be a material reward. In the past few years it has been the experience of many engineers to have had charge of work on which the foreman and machine operators were drawing 50 to 100 per cent more pay than the engineer. Knowledge of this does not create respect for the profession by those employed on the work, nor does it increase the engineer's self respect and confidence in his position of authority. Highway engineering requires as much training, experience, and application as dentistry or the law and as a profession is held responsible for the condition of the public highways, which are the main arteries of business in the country and which affect the individual and community more intimately than any other public work. Therefore in the light of fairness and good business this profession should also be recognized by proper compensation, otherwise it will be difficult to interest able engineers in the work.

THE QUALIFICATIONS NECESSARY.

The qualifications for a highway engineer do not seem to be generally agreed upon. It is frequently stated that this position requires only from 10 to 25 per cent technical knowledge and the remainder common sense. The natural consequence of such statements is to mislead the public and discredit the profession. It is true that the work requires the exercise of a great deal of common sense, but that is fundamental and true of any other important work. The highway engineer must have a groundwork of engineering knowledge, acquired through years of practical experience and study or by technical schooling. Without advanced technical training a man is greatly handicapped in engineering, but on the other hand, experience proves that men who have overcome this handicap are generally the most efficient.

Highway engineering is a new science, in the process of development, and the man who can accumulate and systematize knowledge of this subject as it develops will make a successful highway engineer, provided he has the preliminary training or engineering experience as a foundation. Actual training in this branch of work has not given engineering colleges much concern up to the present time, which, however, is not a serious matter, for traffic conditions have changed so radically in the past few years that the principles involved are entirely different. We are now at the opening of a new transportation era and the volume and importance of contemplated highway work calls for the special training of a large number of men. At the same time it is realized that engineering colleges are not generally equipped to give this training, and therefore it falls upon the State highway engineers to lend assistance in directing the work of the student, so that upon leaving college he will not have to serve such a long apprenticeship before taking charge of work.

To efficiently perform the duties of highway engineer requires not only technical qualifications, but also knowledge of public affairs, administrative ability, capacity for detail, and the knack of handling men. The engineer devoting all of his time to the work is in the best position to study traffic conditions and the economics of the situation, to advise the govern ing boards, and direct public sentiment along proper lines.

DEPENDENCE UPON THE ENGINEER.

There is a growing tendency, especially in the Western States in which highway departments have been organized for several years, to place the entire responsibility for highway management in the county upon the highway engineer. Boards of supervisors have other interests demanding their attention and are placed in authority primarily to carry out public policy and to protect the public interests. It is not expected that they are qualified to direct engineering operations and they gladly receive the cooperation of the engineer if convinced that it is cooperation and not interference which the engineer offers. But an engineer should not assume such responsibility unless he is willing to apply a tremendous amount of study and work to the task. He must make a study of the present and prospective tonnage and passenger movement on the highways, of the availability of road materials and shipping facilities, and also of the economical types of road and bridge construction to meet the various conditions, and must inform the people of their needs in such a way that funds will be provided to carry on the work. A survey and accounting organization has to be worked up so that adequate and complete plans and supervision will be provided and comprehensive cost data made available; also that traffic and service records may be kept, and all factors governing road policy and administration tabulated and orderly arranged. There is practically no end to the detail connected with highway management if properly handled.

It may not be amiss at this time to go into the general policy of highway administration, and to caution the Federal and State authorities of the danger of too rigid standardization. General standards and principles must be established, of course, but individual initiative must be given full opportunity for development. Highway engineering is an art, not a trade.

RECOGNITION AND COMPENSATION.

Getting back to the problem of engineering organization and taking all conditions into account, the prospect does not appear at all difficult for the immediate future, provided, however, that there is recognition of service and proper compensation, for then the profession will attract engineers who have been in military service, having previously had training and experience on railroads, highways, or similar work, and whose military duty has forced a respect for detail and given an opportunity for handling men. Not only that, but their observation of the remarkably good road conditions in Europe, where the actual construction is nothing to speak of but where the maintenance system is so amazingly complete, has awakened many of the engineers to the highway possibilities in this country and a consequent desire to participate in the work. This situation will undoubtedly take care of the immediate needs, but some means must be devised for training the large number of men who will be required to take charge of the tremendous amount of road building to be carried on in the next few years. Experience has demonstrated the need for a combination of practical work with engineering studies, and it would seem expedient for the various highway departments to cooperate with engineering colleges in this respect. This policy in general is in line with the recommendations by Dr. Mann in his excellent report for the joint committee on "Engineering Education." An attempt has been made in Minnesota to follow a similar policy, and a number of subordinate positions in the State highway engineering force have been filled during the summer months by university students, thus providing more efficient help on surveys and inspection and also giving the practical training so necessary to a complete education.

ROADS GIVE WORK TO FARMERS.

The State Highway Commission has recently completed roads in Blaine and Hill Counties, Mont., selected not only to give improved highways urgently needed but to furnish work to farmers who met with losses of their crops last year through unfavorable weather. One of the roads, 6 miles long, in which much gumbo was encountered, was difficult for any kind of travel in wet weather and could only be used for heavy traffic in dry weather. It was graded, subgraded on gumbo, given a clay binder, and topped with a compact gravel surface, and all bridges were built to stand a 20-ton load. All the labor and teams were furnished by farmers residing in the immediate vicinity of the road. This was also true in the work on the other road constructed, which was cut through bluffs and shortened the existing road 4 miles. These roads were built on the State-aid plan, by which the State bore 40 per cent of the cost.

COUNTY WANTS GOOD ROADS.

Winnebago County, Ill., is after better roads and wants them in a hurry. Grant Highway passes through that county and is in bad condition Investigation showed that probably not until 1922 would the State commissioners of highways be able to help Winnebago from the $60,000,000 bond fund recently voted in Illinois, and a movement was started to provide a county fund. It is proposed to vote an issue of $1,500,000, the funds to be used at once in building roads. It is estimated that this amount will build a system of 77 miles of concrete roads. A large meeting of farmers and town people, held December 30, voted unanimously to support the proposition. Farmers voted that they would stand a tax of 6 cents an acre per year for 20 years on their land to take care of the bonds.

TREES TO ADORN ROADS.

H. A. Green, president of the Monterey, Cal. Tree Growing Club, has offered to the State Forestry Department 1,000 live oak trees for planting along the roads. The Forestry Department has approved and put the matter before the State highway commission.

Laying Out, Marking, and Maintaining a State Trunk Highway System

A. R. HIRST, State Highway Engineer of Wisconsin.

IT IS becoming increasingly evident that if our States are to have a completed system of modern highways within this generation, their expenditures must be largely concentrated upon definite and restricted systems of highways, and not spread indiscriminately on all roads, as in the past. In order to make possible this concentration the state highway systems must be most carefully selected, for this policy of concentration will meet much opposition, which opposition will in many cases prevail unless the basic layout is honestly, logically, and adequately made.

Wisconsin has in the past two years established such a system, and our methods of doing it and the lessons we have learned in the doing of it will doubtless be of interest to the States which have, or will shortly have, similar problems.

The whole cost of establishing, marking, administering, and maintaining the Wisconsin trunk highway system and the State's share of the cost of all Federal aid construction on it is made available by appropriating 75 per cent of the net proceeds of the motor-vehicle license fees for these purposes. The remaining 25 per cent goes back to the counties for the maintenance of other main roads.

A. R. HIRST

WHAT SHOULD A STATE SYSTEM BE?

Our conception is that a State trunk highway system is a system of highways interconnecting every county seat in the State, also every city or village having a population of 1,000 or more; offering full access to the agricultural, scenic, manufacturing, and resort interests located within the State; and connecting also with the principal highways of all surrounding States.

We believe that the State trunk highway system should include approximately 10 per cent of the total public highway mileage lying outside the limits of incorporated cities and villages. This percentage may be high for some of the more thickly populated States and it may be low for the sparsely settled ones.

The present Wisconsin State trunk highway system comprises 5,000 miles, or about 6½ per cent of our total rural road mileage. This system, however, is not entirely adequate. We expect the legislature will add from 1,500 to 2,500 miles within the next few years, bringing it up to about 10 per cent.

SELECTING THE SYSTEM.

In our State the selection was made jointly by the State highway commission and a committee of five from the legislature, appointed by the governor. There was complete cooperation between the two bodies, and we believe that the result reached jointly was much more satisfactory to the people of the State than action by either body alone would have been.

The first step in the layout was to select and place upon a map all roads in the State which, from the best available information, were the main lines of travel. These were studied very carefully and another map made showing a tentative system including the most desirable routes, but not exceeding the maximum mileage allowed by the statute. These highways were strategically located so that parallel highways were placed a reasonable distance apart, and so that the areas untouched by any road were approximately equal in territory of equal development. As a result of this very careful preliminary work, it was found that the tentative system coincided largely with the system finally selected.

RECONNOISSANCE SURVEYS MADE.

After this had been done our division engineers made a careful reconnoissance survey of all the routes on the map, together with competing routes, where such existed, and such other routes as seemed to them to be worthy of consideration. This survey was made by automobile; the division engineer, who drove the car, acted as observer, and was assisted by a recorder who kept a record of all features of the road by tenths of miles on a prepared pad sheet. The features recorded included the character and condition of the road and its surface, culverts, bridges, drainage, soil, character of surrounding country, cheese factories, creameries, schoolhouses, farmhouses, mail routes, railroad crossings, turns, hills, bad conditions generally, and all other information of engineering and public interest. The actual mileage on the various routes was, of course, taken. By tabulating these sheets it was possible, in case of doubt between two competing routes, to get a very close idea of their comparative merit.

After all probable routes had been surveyed hearings were held at each county seat. At these hearings large scale maps showing the routes under consideration in the county and vicinity were displayed, and the advocates of all routes, especially the competing routes, were given full opportunity to present their views. As evidence of the interest in the layout, most of these county hearings were attended by from three to six hundred people, and much valuable information was obtained. The important result, however, was that the people knew that all possible routes had been investigated and that the advocates of all of them had been given a fair chance to be heard.

ARRIVING AT FINAL LAYOUT.

After a series of hearings covering a particular section of the State, the State highway commission and the legislative State trunk highway committee, which sat jointly with the commission in many of these hearings, met at Madison and determined the official system for that section. Important considerations in arriving at the final layout were: The population served, the grades, the supply of materials locally available for construction and maintenance along the various roads, and the transportation facilities available where local materials were not to be had. In many cases the choice between competing routes was determined by the character of the soil over which the two passed.

In laying out the 5,000-mile system in Wisconsin about 7,500 miles were surveyed. About five months were required by all the necessary operations and the total cost to the State was approximately $20,000, or at the rate of $4 per mile for each mile finally located on the system, including the cost of the final survey (described hereafter) made in the spring of 1918.

The maintenance of this system was taken over by the counties under the general direction of the State on May 1, 1918, as required by law. As early as possible in the spring of 1918 a second survey of the lines as finally established, connected, and numbered was made. This survey was for the twofold purpose of recording the condition of the highways by tenths of miles at the minute State maintenance began, and for the second purpose of determining the location of the mileposts and patrol sections, the information to be placed upon the direction and danger signs, and their location, etc.

We feel that a condition survey is necessary at the exact moment the maintenance of the system is begun, first, to obtain an accurate measurement of the system as finally laid out, and, second, to make a record of the exact condition of the system so that improvements made can be later registered and compared with the original condition.

We have worked out a system of progress reports using colored crayon and tack entries on charts and maps so that the past and present condition of any section of the system and all structures on it can be determined at a glance.

A tabulation of this final condition survey (made as of May 1, 1918) shows that there were actually 4,999 miles of road on the system subject to State maintenance.

MARKING THE SYSTEM.

Our State trunk highway law provided that each State trunk highway should be given a number, which should be displayed along the road itself in a standard design, similar on all State trunk highways except the number. The State trunk highways are numbered in order of their length in miles from 10 upward, the longest (456 miles) being number 10. The idea in selecting 10 as the lowest number was that every highway number should contain two digits and thus give uniformity.

After considering a large number of designs for the standard marker it was decided to use a triangle containing at the top the words "State Trunk Highway," then the number in large figures, and in the lower point of the triangle the word "Wis." The triangle is 10 inches wide at the top and 13 inches long, and is placed on telephone poles on a white-lead and oil-paint background 18 inches wide, the triangle and lettering being coach black. We find that it is advisable to be rather profuse with these road markers. The white bands are just as valuable as the marker itself in outlining the route. Where a turn should be made the white band is widened to 30 inches and an "R" or an "L" stencilled beneath the marker in the white field. These markers were placed upon the telephone and telegraph poles, fences, culvert-end walls, and in some cases on boards nailed on trees, where other objects were not available.

COST OF THE MARKING SYSTEM.

By the cooperation of the 71 counties the whole system was marked in one week. Each county did the marking within its limits, the stencils and instructions being furnished by the State highway commission. The cost of marking in the counties varied with the care taken, the complexity of the roads, the length in the cities, etc.; the highest county rate per mile was $5.25; the lowest $1. The total cost of marking 5,300 miles was about $9,000, or at the rate of $1.70 per mile. The system of numbering the highways has proven to be very satisfactory. The principal highways are now called by their numbers just as naturally as people call trains by number.

We have erected county line signs and State line signs giving the name of the two counties and the county highway commissioner's name and address. On the same principle every patrol section has a sign at each end giving the name of the patrolman each way from that point. These two types of signs are placed so that the traveler may know who is responsible for the maintenance of the section of road over which he has just passed and of the section into which he is passing. We have found these signs very valuable in stimulating the natural spirit of competition and pride, which should exist in patrol work.

MILEPOSTS AND DIRECTION SIGNS.

We have also set up standard mileposts or markers showing the State trunk highway standard design and number and the mile number measured from the east or south end of that especial State trunk highway. These mileposts serve to tie our office records to the road itself, and also enable any traveler encountering good or bad conditions to boost or complain to us, as the case may demand, and enables us to locate the exact place mentioned. Culverts and bridges are numbered and tied into the mile numbers—thus the first culvert in mile No. 25 on trunk highway 10 is 10–25–1, and the first bridge is 10–25–11, etc. All mileposts are of wood and cost us about $1.50 each erected.

We are erecting about 2,000 direction signs. These are board signs painted white with black lettering. They are divided into "on system signs"; that is, signs at intersections directing both ways to places on that State trunk highway or beyond, and giving the mileage; and "off system signs", located at intersections with other roads and directing to important points not on the State trunk highway system. These "off system signs" are located only at the intersection with the one road which should be taken from the State trunk highway to the point in question.

SPECIAL METAL DANGER SIGNS.

We have also designed and have had made special metal danger signs for railroad grade crossings and dangerous hills and curves. These are the only metal signs we have used and cost $1.365 each f. o. b. Madison. Caution signs stenciled on telephone poles or other convenient objects are used where there is no real danger if reasonable care is exercised. Direction signs and all other signs are erected on wooden or concrete posts painted white.

In addition to the above, all of which serve to outline the course of the system in one way or the other, we expect next year to paint or whitewash the end walls of all culverts, the end posts of all bridges, to place posts painted white at the end of all culverts without end walls, and where the fills are not high and we have no guardrails we will outline the edge of the fills with stones painted white or with occasional white posts.

Including the marking of the triangles (costing $9,000), the total cost of marking, signing, and protecting the State trunk highway system will be $25,000, or at the rate of $5 per mile.

MAPS OF THE SYSTEM ARE NEEDED.

The next thing after the system is laid out, surveyed, recorded, and marked is the publication of a map, which will enable the traveling public to properly select their routes and the numbers. We are publishing a wall map (scale 1 inch equals 6 miles) showing all roads in the State, with the State trunk highway system, and the secondary roads outlined in red. This is small enough for general office use, and while the sale of such a map is limited, it is valuable for display in hotels, garages, clubs, etc.

The map for general public use in touring is published on a scale of 1 inch equals 16 miles. In addition to showing the numbered and marked State trunk highway system and the principal secondary roads, points of historic and scenic interest and State institutions are also located and numbered. Accompanying this map is a little booklet on Wisconsin, giving her history, an index to historic, scenic, manufacturing, and State property features located on the map, some record of its agricultural and manufacturing resources, and other material of interest. These maps are sold for 10 cents each.

CONCENTRATE ON TRUNK SYSTEM.

All Federal aid construction is concentrated on the State trunk highway system. The legislature has also provided that at least one-half of the State aid money, together with the county funds, should be expended on this system. In so far as possible these funds will be used to construct those places at present impossible to maintain in their present condition. We have no hope of reconstructing the entire system in an adequate manner for several years, but are using the limited funds available to get rid of the road terrors and thus strengthen the weak links in the transportation chain.

In our State aid construction for the next year or two we are going to relax from our previous standards and convert construction funds into heavy maintenance work covering much more mileage. This will be true in both grading and surfacing work. Results secured by our gang maintenance this year fully justify this extreme departure from our previous practice if good patrol maintenance is immediately established.

MAINTAINING THE SYSTEM.

We do not believe that a State should lay out a state trunk highway system unless from the instant it is laid out it is maintained by the state at the expense of the state. The maintenance should be either under the direct control of the State highway department or, if under county control, subject to direct State supervision.

If a State lays out a State trunk highway system, it must at the same time provide for its adequate maintenance. The counties will not maintain it, the towns will not maintain it, neither will the cities nor the villages, because all of them reason that some day the Federal Government or the State, or both, are going to build it, or at least help to build it on very favorable terms, and why should they spend any money on it for either construction or maintenance. We hold it a truism that the establishment of a preferred system of roads by any unit of government should carry with it the immediate maintenance of that system by the establishing unit. The State should pay for the maintenance, for State control without State money is bound to be difficult, not to say impossible, to administer. The same general principles would absolutely apply to any Federal system which might be laid out.

There is much to be said for the Wisconsin system, in which the State has general supervision, the county organizations carry out the details of the maintenance work in accordance with State requirements, and the State repays the cost to the counties when the work is properly done. A one year's trial of this method has worked out quite well in Wisconsin. We can not say that it has or has not worked out as well as would a system of exclusive State control. Under the plan of organization, long established for State aid construction, county maintenance directed by the State seemed to be the logical method, and we will say that almost without exception the county organizations have cooperated wonderfully well and have gotten excellent results. Where they have not, our law gives the State department adequate remedies.

WISCONSIN'S PATROL SYSTEM.

We believe in the patrol maintenance system. Patrol sections of proper length, whatever the character of the highway, should be placed in charge of a patrolman who is solely responsible to those above him for the condition of his section. We have established about 480 patrol sections in our 5,000 miles of highway, varying in length from as little as 6 miles on very bad earth road stretches, to as much as 20 miles on some of the macadam truck patrol sections. We believe that the average patrol section should be not more than 7 miles if the road is an earth road in average condition.

Patrolmen in Wisconsin were secured through advertisements in local papers after the patrol sections were determined. Applicants were asked to appear at the county seat and were looked over and questioned by county authorities and a representative of the State highway department. Starting salaries were fixed at from $120 to $135 per month and the patrolman is required to furnish a good team and a wagon. The county furnishes the remainder of the tools, consisting usually of a small four-wheeled road grader for two horses; a road planer or road drag, or both; plow, shovels, picks, brush hooks, etc. Patrolmen are required to sign a contract and to give a bond for $500.

ROAD SCHOOLS FOR PATROLMEN.

After the selection of the patrolmen county road schools were held at each county seat at which the division engineer and the county highway commissioner explained in detail the methods to be used in patrol maintenance. A pamphlet on patrol maintenance was also published by the commission giving instruction for the gang and patrol maintenance of the various types of road.

Of the 480 patrolmen originally hired 75 were discharged and replaced before the end of the season. It was necessary in many cases to raise the compensation so that at the end of the season the scale was from $120 to $140 per month. Next year, unless conditions change, we expect to pay more, especially for the better patrolmen. The patrolmen are engaged continuously during the maintenance season, which with us lasts about eight months. In the winter season we expect to use them a part of the time for winter hauling of surfacing materials and for snow removal, where the counties are forced to remove the snow owing to the failure of local units to do so. The patrolman's wagon is marked with the standard triangle and number and he is required to wear a distinguishing badge, to display a flag when off the road during working hours, and to make daily and semimonthly reports.

EXPECTATIONS HAVE BEEN MET.

In general the patrolmen have more than justified our expectations. At least 65 per cent of them have given excellent service. About 20 per cent are on the division line between good and poor, and about 15 per cent will not be with us next year. We have had a small percentage of sections which as a result of a combination of disasters have given us considerable worry. We believe that when a section threatens to become a continuous "hoodoo" the only thing to do is to take it in hand and devote the organization's time and money to it until it is brought up to standard.

In 1918 we will reduce the length of many of our patrol sections and thus increase the number of our patrolmen. This increase will probably be about 20 per cent and will cut the average length of our sections from 10.5 to 8.7 miles.

GANG MAINTENANCE ORGANIZED.

In addition to the patrol maintenance we organized each county for a certain amount of gang maintenance. This includes heavy road machine grading; scarifying, shaping, and placing light resurfacings on old gravel and macadam roads; also the surface treatments. Roughly the expenditures for maintenance have been divided, one-half for patrol maintenance and one-half for gang maintenance. The expenditures in 1918 were at the rate of about $250 per mile. The cost of patrol maintenance per mile on earth and gravel roads averaged $125, the remainder being expended for gang maintenance or maintenance of the more expensive surfaces, such as macadam.

Wisconsin made an error in distributing the funds available for maintenance to the counties pro rata with the State trunk highway mileage lying in them. The distribution of maintenance funds should be made by the State department on the basis of maintenance needs. Other States should not repeat our mistake.

MAINTENANCE EXPERIENCE.

It may be interesting to summarize briefly some of the conclusions we have reached as a result of one year's State maintenance. These may not be final but they seem well founded on our experience so far.

We find that earth roads of light clay or loam are easy to maintain either by dragging and planing or with the road grader, providing we have a rain about every 10 days. Continued dry spells are almost as troublesome as continuous wet spells, especially on light soils.

The two horse four-wheeled blade grader is the most effective tool for earth and road maintenance. The road planers are the second most effective, but must be built much stronger than usually shown or sold if they are to stand the pounding of constant use.

We are going to start an intensive campaign for applying sand or gravel light surfacing on earth roads which are sticky or slippery after rains. We have been astounded at the results from light (2 to 4 inches) sand and gravel coatings on heavy clay soils if followed by patrol maintenance. This is probably the most valuable lesson we have gotten from this year's maintenance experience.

We have learned that well-maintained earth roads need very little crown. The flatter and wider an earth road the better if it has good drainage and is kept constantly smooth. The same is true for all other types.

KEEPING UP SAND ROADS.

On sand roads we find that marsh hay and straw are effective if covered with sand at the time of application and that sand much prolongs the life of these materials. Cedar bark and cedar shavings are the best temporary sand coverings. Our tar-hay experiment on sand was quite successful but this method of sand maintenance is entirely too expensive, costing at least $700 per mile per year to maintain a good 16-foot composition surface. We believe that the economical thing to do with sands is to cover them with good clay or gravel as rapidly as funds permit. Tar-hay, hay, straw, and weeds wear out rapidly and are far more expensive in the long run than a clay or gravel permanent treatment under even very disadvantageous and expensive hauling conditions.

The roughest roads on the State trunk highway system have been the waterbound macadam roads which have been surface treated in past years. It is probably theoretically possible to maintain a limestone macadam road with surface treatments, but with the instruments of maintenance in the way of man power we have to use in these days effective results are very difficult to obtain. The untreated water-bound macadam roads maintained with light coatings of sand, pea gravel or stone screenings, or even with a road machine, have been more satisfactory than have the treated macadams that were not properly maintained from their construction. We expect as rapidly as possible to scarify all of our worn macadam roads, widen them to 16 or 18 feet, and cover them with a coating of two or three inches of fine gravel.

We have about given up the water-bound stone macadam road as too expensive a proposition to maintain. Some of the penetration macadams bound with tar or asphalt have given much better service than expected and have shown themselves superior in maintenance possibilities to any water-bound structure we have built. This is another reversal of a former opinion.

GRAVEL ROAD EASY TO MAINTAIN.

We have found that the most satisfactory cheaply built roads to maintain are the gravel roads. We have scarified many miles of old gravel roads and at a cost of $200 or less per mile have produced a surface very satisfactory and easy to maintain. The more experience we have with gravel the more convinced we are that it is the lowest cost surfaced road, both to build and maintain, and much superior to water-bound macadam. We believe that the particles of gravel in the top four inches of a gravel road should not be larger than one inch, and we would crush even finer if it were not so expensive to produce fine crushed gravels. Gravel roads give the best and smoothest service without surface treatments. If it is necessary to treat them to eliminate dust use very light oils and don't try to build up a protective coat.

We have found trucks and tractors not generally satisfactory for patrol maintenance. Trucks give too much opportunity for joy riding, are economical only when used for hauling, and then only when rapid loading and unloading facilities are available. Tractors give fair service but to make them economical the sections must be so long that a part of the road lies undragged for too many hours after it gets in condition for dragging. It is a fact that with both the trucks and tractors that if the patrolman starts as soon as a road is fit for dragging, on the long sections the road has become too dry before he completes the two round trips necessary. Furthermore, neither tractors nor trucks provide the ditch and shoulder maintenance that can be gotten with a team. We are going to distinctly discourage the use of both trucks and tractors in patrol maintenance except as supplements to team patrol, and stand by old Dobbin.

MAIN ROADS NEVER SO GOOD AS NOW.

Summing up the maintenance results we can say that on the State trunk highway system in Wisconsin, despite the fact that our construction has been cut to less than half of the normal due to war conditions, the main roads in Wisconsin were never so good as they have been throughout this season. We estimate that in one year we have improved the average condition of the 5,000 miles at least 50 per cent. Competent estimates are that in the one year the increased number of miles per hour which can be safely averaged by auto over the State trunk highways is 7 additional miles. This improvement and this increased mileage per hour means much.

We believe that any State can equal or surpass this record at an average cost of about $250 per mile per year. If more money can be made available the first few years, so much the better. We have learned to have the greatest respect for the less expensive methods of maintenance and construction which we did not entertain heretofore.

We feel distinctly confident that if one year has enabled us to produce the results which have been produced, a succession of years will give us a passable highway system at an expense within our means. Maintenance will bridge over the gap which there must be between our present practically unroaded condition and the ultimate system of adequate highways built to bear modern traffic, which all States are going to have as fast as these systems can be financed and built.

Probably the best commentary on the maintenance results of this year is the fact that at the November meetings of our county boards many of the counties adopted county trunk highway systems to be maintained in 1919 by the counties by the patrol system. It is probable that the total mileage on these county systems is half that on the State system, so that Wisconsin will have 7,500 miles of patrolled highways in 1919.

A PLEA FOR STATE MAINTENANCE.

The States which are doing nothing to maintain through routes until they are constructed are making a grave mistake. · Much can be done with the most unpromising system of roads if moderate maintenance funds are expended efficiently under the patrol system. It must be conceded that earth roads and the light types of temporary surfacings fail upon certain occasions to give 100 per cent service every day in the year, but on a surprisingly large number of days they can be made practically as good as any road.

If any State expects to build a complete modern State trunk highway system within a year or two, it need not establish State patrol maintenance; if it can not, we urge it to get into the real maintenance game and wrest the best results possible out of what it now has in the way of roads.

If an as yet unroaded State, with insufficient funds available for construction on a large scale, wishes to do the most for its roads and for its people, we are convinced that for a few years it can do it by expending its money largely in intelligent maintenance, good grading and temporary surfacings over the entire system, than by building a few miles of high-class construction in isolated stretches. In the average State $2,000,000 a year will adequately maintain and do much to improve a road system of 7,000 miles or more; it will build each year about 80 miles of modern road.

Eventually we must all build certain of our main highways of the highest type of construction. We must immediately construct in this manner certain stretches which can not be maintained so that they may bear the traffic which does or should use them, but the great mass of roads, even the most important roads, in the average state must wait several years before they can be rebuilt adequately. Why not recognize the fact and devote less state funds to construction and more to maintenance, not only of the inadequate road structures already built, but of the common earth roads as yet untouched?

I know this is unorthodox, especially coming from a State highway engineer, but if it be treason, make the most of it. For the next few years, if we have our way, Wisconsin is going to devote herself largely to maintenance and temporary grading, draining, and surfacing. When we do spend large funds for final construction in that period, it will be for adequate widths of concrete or brick or whatever type may surpass these in final economy and ease of maintenance. These roads which can not be maintained unless surfaced and which we are financially unable to build of the final type, will be built largely of fine crushed gravel, surfaced at least 16 feet wide.

The Elimination of Grade Crossings with Railroads Demands Serious Attention

M. W. WATSON, Acting State Highway Engineer of Kansas.

THE ever-increasing traffic of motor vehicles on the public highways accompanied by high speed and careless driving has directed the attention of highway officials to the necessity for safeguarding the public not only from their own carelessness but from that of others as well. Railroad grade crossings are, without doubt, the source of a large percentage of all accidents.

During the months when motor traffic is at its height we hear almost daily of some car being demolished at one of these places, and many times an entire family killed. These things seldom impress us to any great extent until some time, sooner or later, we are called upon to face it among our own family or circle of friends.

Aside from the human standpoint the cost to the railroads is quite large when considered over a period of a few years. Expensive litigation often follows one of these accidents and the railroad company is often obliged to pay damages when the driver was in the wrong.

Many times the driver of the car is wholly in the wrong, but we must provide safety devices to protect the innocent from the careless and unthoughtful person.

In the thickly populated sections of the country railroad crossings occur at frequent intervals and no one who has any regard for his own safety can help but feel a pronounced degree of uncertainty whenever he crosses one of these tracks.

PRESENT LAWS ARE INADEQUATE.

Until the development of the present-day motor traffic, with the exception of roads and streets in the most densely populated portions of the country or in large cities, very little attention was paid to the elimination of grade crossings and from data collected from the different States it is very apparent that the laws on the subject of grade crossings at the present time are very inadequate.

Accident Bulletin No. 65, of the Interstate Commerce Commission, which covers the three months of July, August, and September, 1917, shows that during that period there were 1,054 accidents at railroad grade crossings. In these accidents 553 persons were killed and 1,278 injured; of which number, strange as it may seem, one of the persons killed was a railroad employee not on duty.

M. W. WATSON

The Legislature of Kansas when creating the State highway commission provided that in the establishment of a system of county roads comprising from 10 per cent to 25 per cent of the total road mileage in each county, that the board of county commissioners and county engineer should as far as practicable eliminate all railroad grade crossings either by subways, viaducts, or by relocation of the highways. It is further provided that in the event that the county officials fail to give proper attention to crossings, the State Highway Commission can by order cause the elimination of them.

Grade crossings may be divided into several classes, as follows:

1. Crossings which can be eliminated by the construction of a subway under the railroad;
2. Crossings which can be eliminated by the construction of a highway viaduct over the railroad;
3. Crossings which can be eliminated by a relocation of the highway;
4. Crossings which can be eliminated from the main traveled highways by diverting the travel to other roads.

ELIMINATION BY SUBWAYS.

Elimination by the construction of subways is an expensive proposition and involves many pertinent features. The topography in the vicinity of the crossing must be such that its construction will be feasible. In Kansas we find that in many cases the crossings are so low that the construction of a subway would not only be extremely expensive, but would be impracticable for lack of satisfactory drainage and due to the probability of it filling with drifting snow in winter.

An important point to be considered in the construction of a subway is the clear view of approaching vehicles that can be obtained through the opening. We have frequently noted subways that were constructed to eliminate grade crossings which are more dangerous to travel due to collision between vehicles than from the railroad itself.

Our practice requires that the subway carrying a highway under a railroad or an electric railway shall have a clear roadway of not less than 18 feet, a clear head room of not less than 14 feet, and the subway shall be laid out, wherever practical, so that there will be an unobstructed view of the center line of the road for 300 feet at a distance of 150 feet on either side of the subway.

General practice throughout the country seems to require the railroad companies to bear the larger part of the cost of constructing subways. Many times the railroad is required to build the structure and pay for the excavation within the right of way, while the highway officials pay for the excavation outside the right of way and for the pavement.

It is unnecessary to dwell upon the details of subway construction, which are purely technical and are undoubtedly familiar to the members of this organization.

VIADUCTS ARE TOO EXPENSIVE.

The overhead crossing, like the subway, is an expensive method of elimination and it also requires a proper topograph, otherwise the expense frequently makes this method impractical. Like the subway, the overhead crossing is generally prohibitive in Kansas due to the general level-lying country, necessitating expensive approach grades.

In constructing the viaduct it is necessary to take into account the matter of clearance and the proper approach grades to the structure. Frequently overhead crossings are constructed with very narrow, steep grades which are an obstruction to the highway. In some States the laws are explicit in regard to clearance required.

Kansas practice requires that the bridge structure shall have a clear roadway of not less than 18 feet in width and that the approaches thereto shall be at least 24 feet wide. The grade of the approach must not exceed 5 per cent. The clear height of the structure is required to be at least 22 feet above the top of rail.

RELOCATION OF THE HIGHWAY.

A common method of eliminating grade crossings is the relocation of the highway, especially trunk lines or principal county and State roads, so as to avoid the crossings. This is especially true in the Middle Western States where railroads were originally run so as to get into the largest possible number of townships and counties, thus crossing many sections diagonally. It has been found from our experience that the cost of relocation when a hard surfaced road project is contemplated will be practically nothing, the cost of the land required for the relocation being overbalanced by the saving in the square yardage of pavement, and it is also a decided advantage to the traveling public, since the length of road is decreased.

The Kansas law provides that the railroad companies shall pay from 50 per cent to 75 per cent of the cost of the new right of way, while the county or the township, as the case may be, shall pay the balance, and that the cost of constructing the new road shall be divided in equitable proportions as determined by the State highway commission.

The commission has ordered the elimination of 159 crossings by relocating the highway to parallel the railroad. Very few of these crossings have come to the point of settlement and the ones which have been completed have been settled by agreement between the board of county commissioners and the railroads. Six of the orders have been rescinded.

DIVERTING THE ROAD TRAFFIC.

In many instances the crossing can be eliminated from the main traveled road by diverting the travel to existing laid-out roads which have not previously been used due to their not having been placed in proper condition for travel. In this case the entire expense is usually borne by the highway unit.

Too little attention is given to legislation for grade-crossing elimination and when laws are passed the authority is usually vested in a public utilities or service commission which is primarily interested in the railroad's viewpoint, and in many instances neglects the best interests of the highway. Laws similar to the Kansas law which vest the entire authority in the highway commission should be given careful consideration.

In addition to the separation of grades or other means of eliminating and protecting grade crossings a campaign for the education of all motor-car drivers should be promulgated. A person before being allowed to drive a car on the highway should be required to pass an examination on certain rules of the road, with special reference to safety, not only for his own protection but for the safety of others as well. We can not do away with railroad accidents within a reasonable length of time by eliminating crossings, as the expense necessarily limits us to a certain number each year. For this reason we must take some precautionary measure to instruct and educate the public in addition to elimination of all possible crossings.

Coordinating the State Highway Systems of the Various States

C. M. BABCOCK, State Highway Commissioner of Minnesota.

COORDINATION of highway systems, both with reference to county and State lines, is one of the important phases of the highway question.

I presume that every member of this convention has experienced more or less trouble in obtaining coordinated improvements among the various counties of his State. Remembering this difficulty, when we were proceeding with the full authority of the State behind us, how much more vexsome becomes the question when we address ourselves to the problem of obtaining coordinated improvements between the various States with no authority beyond our State line.

This question, however, is just as important as it is difficult to solve. There is no doubt but the impetus given to the road-building program, both by development in highway transportation methods and the object lesson of broken-down rail transportation in the early days of our participation in the war, will result in an era of road building, which in the character of the roads built and in the mileage improved will exceed the wildest dreams of the good-roads enthusiast of only a few years ago.

C. M. BABCOCK

NECESSITY FOR COORDINATION.

But this road-building program will not serve its greatest good unless the improvements made in one State are undertaken with a view to what is being done in the adjoining Commonwealths. What the people want and what the Nation needs are roads which begin somewhere and lead to somewhere and, if the ideal is to be approximated, it will make no difference if these "somewheres" are located in different States.

We have been, and are, passing through a period of evolution in all the phases of the highway question. It is not so many years ago that we were building roads in many of our States on the "road district" plan, the limits of the district embracing only 4 or 5 miles of highway. From this small unit we advanced to the township plan, which made all the roads in one township a district and provided for a system of improvement extending over a maximum area of 6 miles square. The township unit was supplanted by a county unit and this in turn by State roads, which is now the maximum unit in the country.

Now, while it is probably true that a large proportion of our roads will be constructed on the basis of the State as a unit, so that State highway systems are possible, we will have to operate with a view to national needs and this will require coordination between the State highway systems, just as our individual State needs has forced coordination between county highway systems.

To me a State highway system is destined to be nothing more nor less than one of the 48 units of the entire highway system which will bind closely together all parts of this wonderful country of ours.

That highway transportation, one of the three forms of intercommunication between the various communities of our country, is of the utmost importance to the fullest economical development has been demonstrated most clearly through the operations of the various highways transport committees during the war. Reaching to the very doorstep of the Nation's population, affording an outlet for products never before marketed, and bringing to the inhabitants of the rural districts the output of factory and mine and forest, the highways must be improved, not upon narrow and crazy-quilt methods, but upon a comprehensive system which will serve not only the county or the State, but the entire Nation.

WILL PROVE COMPLEX PROBLEM.

In some States this coordination of highways systems will prove rather a complex situation, especially where the boundary lines are mere imaginary lines drawn across the map but which definitely mark where the road system of one State must stop and that of another begin. In other cases, where the boundary line is a river or some other natural barrier, the question will be far more simple. Here the systems of the adjoining States, in all probability, will be forced to coordinate by the converging lines of traffic.

Take, for instance, the case of Minnesota. Most of our eastern boundary is fixed by two rivers, the Mississippi and the St. Croix. All of our roads which are intended to afford an outlet to Wisconsin naturally converge at the points of location of bridges which span these rivers. Wisconsin, also, in seeking an outlet to Minnesota, builds its roads so as to reach these bridges and, of course, the problem of coordinating the highway systems of these two States practically solves itself.

But to the south and west our problem is entirely different. The boundary line between Minnesota and Iowa is officially described as "43° 30′ north latitude." All of the roads north of that imaginary line are a part of the Minnesota highway system, while those south of it are a part of the Iowa system. There are no bridges to converge traffic upon any particular line; there are no large cities in which any considerable amount of traffic will either originate or terminate; in fact, there is nothing that will force a coordinatiom of the highway systems of the two States.

Yet these systems must be coordinated if the best results and maximum benefits are to be obtained. Minnesota doesn't want to improve a road running south to this line of 43° 30′ only to have it end in an unimproved highway from there south. Neither does Iowa want any of its roads leading north to end in impassable highways when this mystic line is reached.

HOW IS COORDINATION TO COME?

Both economy and business sense demands that this coordination be brought about in some way. But how this is to be done is a problem, the solution of which is far less apparent than the demand for the formula.

Of course there has been much commendable cooperation between the highway departments of the various States, thanks to the good offices of this organization, but with an era of extensive and intensive road construction confronting the departments of every State, it is evident that the most direct cooperation now becomes necessary.

There are only two ways in which this coordination of State highway systems can be obtained. The first of these is by Federal supervision which will compel one State to lay out and construct its system with a view to what is being done in the other adjoining Commonwealth. The second is by voluntary cooperation, sanctioned, or ordered by the legislatures of the various States, which will result in each State taking into consideration what is being done by its neighbors.

To the first plan there are many objections. Among these might be mentioned as the most pertinent that the various States are not likely to take kindly to too much Federal supervision, preferring to retain complete control over all things relating so intimately to the affairs of the State as do the highways, and also that Federal supervision will result in placing about road construction entirely too much red tape for the welfare of the roads.

MUST BE VOLUNTARY COOPERATION.

The second proposition, on the other hand, has, so far as I can see, only one serious defect and that is the one which will be apparent to all. It is, briefly stated, "Will the States actually cooperate if working on this plan?"

My idea of applying this plan is to have the legislatures of the various States require the highway department to communicate officially with the highway department of the adjoining State before undertaking the improvement of any road which leads to the State line. If it is found that each State is planning improvements which do not coordinate, the highway departments should then endeavor to agree on changes which will make the improvements coordinate. If they are unable to agree, they should then be instructed to report the diagreement to the governors of their respective States, who, as a last resort, could leave the matter to arbitration.

Of course, most of the actual lines of improvement will naturally coordinate as the roads are pretty well designated by lines of traffic and the most of the work in this direction would be to obtain improvements at the same time on both sides of the State line. If this is done, the roads will become continuous thoroughfares, similarly improved and likely to remain in a similar condition for a considerable length of time.

BONDS FOR COLORADO ROADS.

At a recent luncheon of Denver business men State Highway Commissioner Ehrhart detailed a program for improving Colorado highways, based on a proposed bond issue of $12,500,000. The system outlined, founded on a report of Chief Engineer J. E. Maloney, includes 363 miles of 18-foot concrete highway and 2,873 miles of graded, hard-surfaced road. It includes detailed improvement of every main road in the State, in addition to considerable new construction. After he had outlined the proposed system the business men voted to ask for an issue of $20,000,000 in bonds, which, beginning in 1921, should be issued yearly as needed.

Snow Removal from Country Roads by Successful Pennsylvania Plan

GEORGE H. BILES, Second Deputy State Highway Commissioner of Pennsylvania

WHEREAS the demand for an open highway in winter may not be of such an imperative nature as during the great world conflict, which has just ended, I believe there are many main arteries of travel that should be equal to the transportation requirements the year around. It is conceded, of course, that the necessity for an open road is not entirely universal; in other words, it does not apply to all our highways, but every State has and will continue to have roads that must be kept open in spite of the arguments and mass of evidence that may be submitted by advocates to the contrary notwithstanding. We must confess that figures can be presented that favor transportation over the railroads instead of over the highways, but the function of a road official gives him little option in a matter that is so vital, at the same time, an actuality.

INCREASED MAINTENANCE COST.

The evolution of other things may work along parallel lines with the evolution of traffic, which it has been our fortune to observe during the last decade. As an example, 10 or 15 years ago and previous to the advent of heavy motor traffic, the ordinary country road of waterbound macadam was maintained annually in first-class condition for between $300 and $500 per mile, while at the present time these same roads cost for upkeep between $1,200 and $1,500 per mile per year, which is a direct result of the change in the character of traffic which has had to be met and is being met quite successfully, and people are generally adapting themselves to these ever-changing conditions. I merely cite this to illustrate the point that it is not a question in this work of snow removal on many of the trunk lines of the economics of certain classes of transportation, but one for the official in charge of the road to master to the satisfaction of the people he is expected to serve by getting traffic through when called upon to do so; in other words, a plain case of fact versus theory.

There is ample opportunity to study the economics of the work itself when the snow is removed from certain types of improved highways from year to year, for it can be safely said that the keeping of the surface free from snow is a great benefit to the road, allowing more uniformity in the action of frost and other elements and tending to neutralize their effects. We have concrete examples of this on some of the modern types of highway in our State, especially in the populated centers where the snow has been piled from the footwalks a considerable depth along the sides of the street and traffic has been permitted to cut a track through the center, which eventually wears down to the surface of the pavement, exposing a limited area to the action of traffic and the elements, leaving the sides protected. The subgrade under the center of the pavement, therefore, thaws first and the sides are upheld by frozen earth. This condition either fractures the pavement or leaves it supported so that traffic will. It would be advisable under such circumstances, if the snow can not be removed entirely from these highways, to keep the center covered with snow of not too great a depth to seriously impede traffic, in order to protect the road until the snow on the whole surface melts away. This method has also proven good practice along the unimproved highways, many of which carry sleighs and general team traffic principally, where it is not necessary or advisable to remove the snow down to the road surface, as will be explained later.

GEORGE H. BILES

ESSENTIALS IN REMOVAL WORK.

There are two fundamentals in snow removal work that are essential to success, and these are preparedness and perseverance. In speaking of preparedness, one naturally thinks first of labor, equipment, organization, etc., but power to anticipate is of inestimable value and exemplifies the axiom that "forewarned is forearmed." This is made possible through the cooperation of the United States Weather Bureau Office in furnishing forecasts of approaching storms either by wire or mail, depending upon the importance of the districts affected.

Upon the first appearance of snow the work resolves itself into one of perseverance, for it is only by fighting the succeeding storms that success can be attained.

Next comes the material things, the most important of which is organization and system in operation, for we may have a most excellent idea but if poorly executed it usually becomes lost in the maze of confusion. Pennsylvania has a colossal maintenance proposition in the care of over 10,000 miles of all kinds of highways, improved and unimproved, employing at certain periods of the season over 12,000 men, and was fortunate when called upon to keep the highways open to have a system of organization and management based on modern scientific business principles flexible and practicable enough to expand naturally and take over this added responsibility.

SNOW FENCE MOST ECONOMICAL.

Since the organization of the maintenance division of the Pennsylvania State Highway Department in 1913, composed of the assistant engineers, county superintendents, caretakers, laborers, etc., which has complete control of the snow-removal work under the direct supervision of the second deputy commissioner, studies have been made of snow conditions on the main trunk lines, and at a number of places it has been shown that the snow fence is the most economic plan, and considerable fence has been constructed and being put in place at the present time. A fair average price for the fence complete in place at the present time is 50 cents per foot. The design is similar to the standard used by the large railroad companies, consisting of eight hemlock boards 10 feet long 6 inches wide and 1 inch thick placed 6 inches apart and framed together with three braces of 2 by 4 hemlock, placed 3 feet 9 inches apart from the center, to which is bolted at each brace and 9 inches from the top a 2 by 4 support 6 feet 6 inches long. These supports are bolted to hemlock stakes driven in the ground 15 inches, which are 2 feet 6 inches long and made of 2 by 3 inch material. The frame is held in place in front by additional stakes driven in the ground vertically, which are 2 feet 6 inches long and also 2 by 3 material. There is approximately 75 feet of lumber in each 10-foot section of fence.

Just recently a case was brought to my attention where we were expending approximately $200 per year to open the drifts on a certain short, troublesome section of highway in one of our northern counties, on which the placing of 350 feet of snow fence relieved us of further expenditures and promoted great local satisfaction.

The important industrial position of the State of Pennsylvania has afforded an opportunity for probably a keener appreciation of the volume and character of present-day traffic than is probably the case in many of the States. These activities were carried on continuously through all seasons of the year, and means of communication and transportation had to be kept open for their use. Aside from the local demands last winter our State was called upon to keep the main trunk lines open for the use of the United States motor convoys operating between the central west and the seaboard. This route in this State extends from the Ohio State line via Beaver Falls, Pittsburgh, Greensburg, Bedford, McConnellsburg, Chambersburg, Gettysburg, and Littlestown to the Maryland State line, a distance of approximately 225 miles. A more severe winter has not been recorded in the history of the Weather Bureau in our State, and it is gratifying to know that in spite of such unusual conditions the State highway department was able to successfully cope with the situation.

SYSTEM OF HANDLING WORK.

The system of operation for handling this work, established and used by the State highway department, will be described briefly: Arrangements were made with the Weather Bureau office at Pittsburgh and weather forecasts wired both to the main office of the department at Harrisburg and the local designated stations along the line of the important Government motor convoy route. Upon receipt of this information instructions were sent to the various districts to organize men and equipment for action. Stationed at the larger towns along the line of the highway were motor trucks equipped with snow plow attachments, road machines, drags, shovels, etc. The patrol system of men who were employed regularly on the highway formed a nucleus to create the larger forces to handle the work. Each caretaker or patrolman was assigned to a certain particular section with instructions to report conditions immediately to the district head or superintendent, who in turn either wired or phoned the main office at Harrisburg. If the conditions were abnormal, the superintendent of highways of the county communicated with the assistant engineer who arranged an immediate inspection and authorized such steps to be taken as were deemed necessary to expedite the work. The first report of the local man was followed by a postal-card report form giving the details and addressed to the central office. This information was charted as soon as received and a bulletin maintained at all times for general information. If the drifts were unusually deep and the road not opened within 24 hours headquarters was advised, which afforded an opportunity to keep in complete control of the entire work at all times.

When one takes into consideration that a major portion of our State is mountainous and many sections are in altitudes of between 2,000 and 3,000 feet, in which there are stretches of highway many miles in length where there is not a sign of habitation for refuge or shelter, being entirely at the mercy of the winter elements, it would appear that what is possible of attainment in Pennsylvania under such conditions is true of most other States.

Aside from the dearth of labor that was felt over the entire country at this time, there were sections where it was impossible to get labor of any character, and the mountains and villages for miles around had to be scoured for hands, who were transported by sleighs to the site of the work.

FIRST WORK WAS BREAKING A TRACK.

Work began when the heavy fall of snow came in the early part of December by breaking a track with road drags and small V-shaped plows drawn by teams. These were followed by road machines or motor trucks with plow attachments. Turnouts were made at convenient intervals, and as soon as possible thereafter the road was widened to a width of between 14 and 18 feet, depending upon the location. The entire travelable width of roadway was finally opened, in order that traffic would not cut through to the road surface during periods of freezing and thawing, as has already been mentioned.

The snow at first was removed to within 3 inches of the road surface and what did not melt afterwards was removed entirely.

I will qualify remarks just made by saying that these methods apply particularly to improved roads, for if traffic is permitted to track during periods of freezing and thawing on such highways the surface becomes affected to various degrees, depending on the type of the road. We have a number of miles of water-bound macadam roads with bituminous-surface treatments on the main trunk lines, and in order to preserve them during such periods it is essential to distribute the traffic. On the unimproved roads the snow is not taken off entirely down to the surface, but several inches is left for the travel to pack, and as it softens more snow is dragged from the sides, in order to keep the surface comparatively smooth at all times. Rolling of snow is done on the lesser important lines, but this has not been very satisfactory on the roads where there is much motor traffic, on account of the rough condition that results when the surface becomes cut up. The snow being rolled and wet from time to time with sleet and rain storms becomes almost as hard as ice. However, there are a number of roads where the travel is light and used mostly by horse-drawn vehicles where this method will suffice.

HANDLING THE HEAVY DRIFTS.

There were heavy drifted conditions where there had to be special treatment. These were generally located in cuts where drifts were so deep and banks so high on either side that the snow had to be shoveled and hauled out. As soon as any portion of roadway was open shovelers followed cutting openings from the edge of the road to the side ditches at various points along the road, which assisted greatly in the protection and drainage of the surface. In addition to this, all side drainage and culverts were kept open and free of obstruction. This precautionary measure produced very good results, and when the snow passed away in the spring the general conditions were in better shape both as to drainage and surface than they had been at any previous time, in spite of the fact that the roads had suffered greater traffic and increased weight of loads than they had at any time in their history.

Snows up to 12 inches in depth can be handled advantageously with road machines and from 12 to 36 inches, if not too heavy, can be moved with motor trucks with plow attachments with excellent results. The truck is run along one side of the highway and back on the opposite side at the rate of about 4 miles per hour and carries a small crew of men with shovels that are used when the snow piles up in front of the blade, which it will do especially when the snow is wet. When there is a greater depth than 3 feet a large A-shaped plow is used. This implement is 30 inches high at the nose and 6 feet at the back, with 20-foot legs, and 16 feet wide at the back, made of 2½-inch oak plank and 4 by 4 inch framing, held together with movable braces and drawn by a heavy tractor, and it has proven a very economical and effective device. The movable braces are provided for the purpose of permitting vehicles to pass during the operation if it is necessary. The light tractors for this work do not hold the road and have been found unsatisfactory. Mechanical devices are preferable in the majority of cases, but if the drifting is a continuous performance in cuts, it resolves itself into a shoveling proposition.

To keep the roads open under conditions similar to last winter, it costs from $50 to $200 per mile, depending upon the location and other conditions.

IS PART OF MAINTENANCE WORK.

In 1912, when our system of roads was taken over for maintenance, the highway laws with respect to keeping up the roads were not generally interpreted to mean that snow should be removed, for it was an uncommon thing for the local road officials prior to this time to open the drifts. In many places the fences along the line of the highways were removed and the fields used until the snow passed away. If the thaws caused the fields to become soft, in which condition the traffic would do them considerable injury, some effort was made to make the roadway passable. This era quickly passed and with the changing and increased traffic the demands became great for an open highway the year around, and in 1913 this responsibility was assumed by the State highway department and practically all the main trunk lines were kept open from this time on. The records for the winter of 1917–18, which covered the period from December to March, show 22 snowstorms varying in depth up to 16 inches, with drifts ranging from 3 feet to 16 feet in depth, the general average being 4 to 6 feet.

I firmly believe that where statutes permit, and if they do not the legislative bodies should pass enabling measures at once, it should be no longer an optional matter with the road officials in charge of our highways to prevent closing them by snows, for when we consider the enormous winter traffic on some of our roads, argument is futile.

Maintenance of Sandy Roads As Developed by the Conditions Existing in Texas

GEORGE A. DUREN, State Highway Engineer of Texas.

IN TEXAS the maintenance of sandy roads is our great problem, as it is no doubt a great problem in the other States of the Union. We do not, however, recognize a road as being a sandy road as long as there is present even in a small degree a foreign substance that acts as a binder. Our greatest problem in Texas in the maintenance of sandy roads is involved in dealing with the vast areas of Texas where the soils are sands with a minimum amount of binder, where heretofore the most excellent roads were secured across the grass-grown plains by the simple expedient of marking out a path for travel by removing the occasional stones and tufts of grass. The automobile, by keeping to these ruts, found a hard, smooth, and durable roadway, but the same areas when the adjoining lands were plowed, or when the roadway was pulverized by use of plows and grading machines, were found soon to become sandbeds. Generally speaking, the problem of maintenance of sandy roads is a problem of construction, in which some other form of road is substituted for sandy road.

TEXAS SANDY ROADS BUILDING.

The State Highway Department of Texas has at present under way the construction of the following projects as a measure of hereafter maintaining what have been in the past extremely sandy roads:

Brooks Co., State aid project No. 25, 10 miles, at cost of	$30,000
Brooks Co., Federal aid project No. 2, 20 miles at cost of	61,000
Ward Co., State aid project No. 14, 10 miles at cost of	45,000
Ward Co., Federal aid project No. 5, 17.6 miles at cost of	40,000
Ector Co., Job number 136, 7 miles at cost of	25,000
Crane Co., State Job No. 13, 1.5 miles at cost of	4,500
Culberson Co., State project No. 29, 53.6 miles at cost of	77,000
Culberson Co., Federal project No. 1, 50.4 miles at cost of	45,000
Hudspeth Co., Job No. 321, repairing State Highway No. 1, at cost of	8,000
Nolan Co., State aid project No. 19, 9.6 miles, at cost of	54,000
Nolan Co., Federal aid project No. 19, 13.7 miles at cost of	66,000
Mitchell Co., State aid project No. 12, 10 miles at cost of	19,000
Mitchell Co., Federal aid project No. 7, 7.5 miles at cost of	40,000

In the above projects we are, after providing drainage openings and completing the grading of the road to desired cross section and profile, placing on it a road metal of good road building gravel or crushed stone. The projects mentioned above in Brooks, Ward, Ector, and Crane Counties are in areas where not only the traffic must be sustained by a road metal, but in order to prevent the sandy road from blowing away we are covering the shoulders and slopes with materials such as clay and caliche. The projects in Midland, Nolan, and Mitchell Counties differ from ordinary road construction in the fact that where the adjacent lands are under cultivation provision has to be made to prevent the roadways from becoming buried under accumulating sands blown from adjoining fields.

Now, a general treatment in these sections is to elevate the roadway from 18 to 24 inches above the ground line in order that the crown of the road will be swept clear of sand by the wind, and the maintenance consists mainly in occasionally removing the sand that piles up on the leeward side of the road.

WINDBREAKS FOR TEXAS ROADS.

Some attempt has been made to protect the roadways with windbreaks somewhat after the fashion of snow fences, but without any appreciable or marked results in Texas. The barb-wire fences on each side of the road frequently served as an excellent barrier of this kind, as a result of their catching and holding what we call "tumble weeds." A wire fence frequently has the appearance of a dense, heavy hedge of shrubbery, which on close inspection proves to be accumulations of these weeds blown against and entangled on the wires. During the rainy seasons many weeds grow to a large size with wide extending branches. After a long, dry spell the winds uproot the weeds from the soil and blow them across the prairie. They are circular in shape, and at a distance have the appearance of a sheep or a small-sized balloon. After becoming entangled in the wire fence, occasionally when the wind shifts they will move across the country in countless thousands and almost in a solid line, giving the appearance of a vast herd of buffalo.

These weeds make an excellent sand arrester, but they are only temporary expedients.

TREATMENTS OF SANDY ROADS.

There are many different treatments of sand roads in Texas that should be mentioned; namely, in Jasper county pine needles are cheap and plentiful, and have been used to good advantage in mixing with the sand roads with excellent results. In Orange county sawdust is cheap and plentiful and has been used in a few places to fill bad chug holes and as a mud-hole filler with satisfactory results. In Navarro county cotton stalks have been used with some satisfaction in improving a bad sandy stretch of road near Chatfield, stalks being laid in a mat crossways of the road to a thickness of 6 inches and covered with a layer of sand. In the same way wheat and oat straw have been used with some improvement in the traffic condition of a certain strip of the road near McKinney, Tex.

As a general rule, the sandy areas of the State in which are found our most sandy roads are areas which are sparsely populated and, therefore, demands created by traffic are not excessive. The more fertile parts of the State, and, consequently, the most densely populated, are those sections where black waxy soil is found and those sections where the soil is a sandy loam. In the sandy-loam areas the soil is mixed with calcareous deposits or other form of binder, giving the soil stability and enhancing its fertility. Occasionally in these areas the roads are quite sandy, but in general they are of a character generally described as top soils or sand clay.

SAND IN GULF-COAST REGION.

Along the Gulf coast of Mexico and paralleling it and extending back from it a distance of approximatley 150 miles we have sandy roads. These sands are fine grained and are, in fact, sea sands. They are different from the sands found in the famous sand clay roads of North and South Carolina. Our chief difficulty in the past in the construction of roads of this material was due to the failure to secure skilled engineering supervision to carry on the work. Close to the sea where material is mostly sandy silt I know of only one attempt that has been made to construct highways of any importance with this material as it stands, but in every other case construction was made with some other type of road-building material, such as gravel, shell, or some more superior type of road surfacing.

There are some excellent natural highways along the water's edge on Padre Island and other points along the Gulf beach. However, there is no traffic, for the reason that on account of many bays extending mainland, it is not along the line of traffic. These sands, found in almost the entire stretch of the Gulf coast between high tide and low tide, make ideal automobile speedways. The virtue of this type of sandy road consists in the fact that the voids in the sand are filled with water and with salt cyrstals with considerable adhesive value, preventing mechanical displacement of sand particles. The maintenance of these roads consists merely in a sufficient amount of dragging to eliminate small washes and depressions formed by incoming or receding tide water. Roads made of the same material become practically impassable when after becoming entirely dry, they are once disturbed or broken.

We have some exceptions to this general rule, due to the presence of clay mixed in with the beach sand. Texas Federal aid project number 69 from Rockport to Corpus Christi is a project in which construction is performed with the use of beach sand or mud placed in the embankment in the usual way, and after shaping and grading some of the same material is placed wet on the surface in a thin layer and thoroughly dragged while wet. A hard, smooth and, satisfactory surface is secured, capable of sustaining a fairly heavy traffic. In dry weather this surface compares favorably with the best type of gravel road, and in wet weather is satisfactory in every respect, except that it becomes extremely slippery, the cure for which is a thin layer of mud shell used on the surface.

A TYPE FOUND SATISFACTORY.

Mr. R. H. Phillips, county engineer, has charge of this work, and is a warm advocate of the use of this type of construction. He explains that the county authorities found it necessary to construct some roads across some low salt flats, and since there was no other material available they constructed the road out of this material and were amazed at the excellent results obtained.

The northeast sections of the State consist of ferruginous sands which have considerable natural binding properties. Under light traffic they are quite satisfactory, since they are usually compacted by rain and traffic. The South Texas sands are of a calcareus nature, and although they have fairly good cementing quality under traffic they are quickly ground into a fine powder and extremely dusty roads are obtained.

WEST TEXAS WIND-BLOWN SAND.

In west Texas there is a large area of wind-blown sand, which is a very fine quartz sand of a reddish color and which supports little vegetation except shinnery. This shinnery is a form of oak bush only about 18 inches high, which bears abundantly full-sized acorns. In the same area, that is, west Texas, the sand is usually interlaid by rather soft gyp rock broken into rather large pieces, and occasionally this gyp rock is found in pulverized condition, in which case we have a sand which is gypsum by nature, which under traffic becomes a dust. West Texas is subject to continued dry spells to such an extent that methods of maintenance practiced successfully in other States do not prove effective. Approximately 80 per cent of the hard-surfaced roads in the country near the coast are built with mud shell, so that this is an important road material in this section of the State. It compacts with a hard and impervious crust, and with proper maintenance in wet weather it is quite satisfactory, but under continued dry weather or under heavy motor traffic it becomes quite dusty. It is the principal material in the coast country for road construction on these sandy areas. We are having good success in highway construction through these sandy areas with the use of shell, on which shell a bituminous surface is applied. This combination makes satisfactory, economical road construction, the sand permitting good drainage and impervious bituminous surfacing preventing the shell from becoming soft and rutted in wet weather.

The Gulf coast sands are, generally speaking, soft sands; that is, when run between the fingers they do not give that sharp, gritty sensation. They are fine grained and round in shape, mixed with a proportion of silt.

WHERE SAND-CLAY TYPE POSSIBLE.

Leaving the coast and traveling inland the sands become coarser almost in proportion to their distance from the coast, and at a distance of about 150 miles from the coast the sands begin to merge into gravel. In the same area is located indurated sandstone which includes almost every variety of induration, and very often within the space of a few feet it may be found varying from the loose sands to a hard quartzite somewhat like the St. Peter's sandstone found in Indiana and Illinois, from which we derive our Standard Ottawa Sand. The grains, however, are slightly smaller in size, and some excellent sand-clay roads have been constructed with the use of them. Their qualities are perhaps exaggerated to some extent by reason of the contrast between improved roads with their use and the unimproved roads common in this area. Within this belt we have an average rainfall of more than 40 inches, which perhaps is the real reason that satisfactory results are obtained. I am of the opinion that for sand-clay roads to be successful it requires approximately 40 inches average rainfall in a year, unless the clay is of an exceptionally good binding iron oxide variety.

South of San Antonio, where the average rainfall is between 20 and 30 inches, and where 90 per cent is in winter, road construction is rather difficult, and is rendered still more difficult by reason of the calcareous nature of the sand and its tendency to become a powder. These sands are soft sands and can not be satisfactorily worked into sand-clay roads. Road construction, therefore, must necessarily be that of resurfacing with some other material, such as gravel or crushed stone. These are white sands supporting little vegetation except live oak, which occurs occasionally in protected spots in groups of several trees called "live-oak mots."

HIGH-GRADE ROADS TO BE BUILT.

The State of Texas has ample wealth and vast resources, and we now have the opportunity to avail ourselves of the services of our returning soldiers to relieve the shortage of skilled labor. Under these conditions it must necessarily follow, I think, that a great road-building campaign will follow, and our sandy roads will be improved in a similar manner to those improved by El Paso County. El Paso is our most westerly county, and one where sandy roads and low rainfall exist. They improve their highways by the construction of concrete roads and Warrenhite roads. Their roads cost between $20,000 and $30,000 per mile, and are equal in quality to the best types of street paving. Texas is financially able, and we are disposed to improve our sandy roads so that hereafter they will be maintained not as sandy roads but as concrete roads, brick roads, asphaltic concrete roads, and the like.

PROPOSED ROAD PROGRAM.

Judge T. E. Patterson, chairman of the Georgia State highway department, has put before the special highway commission of the legislature a comprehensive plan to secure adequate roads in that State. It is in the form of an amendment to the constitution. It provides a State highway system to be constructed and maintained by the State; the Illinois plan of specifically specifying the road routes of the State system, which will connect all county seat towns and cities by hard surfaced roads; the creation of a State highway commission, appointed by the governor, to consist of a member from each congressional district; a bond issue of $40,000,000, secured by the motor taxes under an amortization plan, work on the roads to be let by contract, to start simultaneously in each of the 12 congressional districts and to be completed within five years; the counties to be left as they are now, with their convict forces to maintain county roads.

Unit Price and Cost-Plus System of Contracts for Public Work

ALEXANDER W. GRAHAM, State Highway Engineer of Missouri.

THE COST of construction always has been and always will be the engineer's main problem. The purchaser demands high-grade design and construction, but he does not want to pay one cent more than is absolutely necessary. The purchaser also demands that the cost of the construction be known in advance. Very often the engineer is told that a certain amount of money is available for this or that piece of construction and is instructed to proceed without delay.

If the engineer is confronted with the limited-funds problem he will naturally turn to the unit price contract, as he knows the number of units to construct, and if he secures a proposal whose unit prices are not above the estimate he naturally feels that the work will be done for the available funds. At this point the old standard clause, which we all insert in our specifications, which states that the contract be let to the lowest and best responsible bidder, etc., presents itself.

ALEXANDER W. GRAHAM

A GUESS PROPOSITION.

Under the system of competitive bidding, contracting is a guess proposition. There is nothing to prevent persons without experience or organization, but who can secure financial backing, from submitting bids much lower than those submitted by reputable contractors, and in a number of cases the lowest bid will be one that is below the actual cost of the work. Now enters the clause in our specifications relative to the lowest and best bidder. How many of you have ever been able to convince the purchaser that the lowest bid was not the best? Invariably the purchaser takes the position that, as the contractor has furnished a gilt-edge bond, and that competent inspection has been provided for, why is it necessary to pay more for the work?

The engineer knows that an inexperienced contractor can not and will not do the work as well as an experienced man would, and yet the purchaser, very often not familiar with construction work, is hard to convince that he will get value received by paying more than the lowest bid entails.

It is human nature to think that the other fellow's game is much easier than the one in which we are engaged. Therefore at practically every letting there will be found at least one bidder who is bidding for the first time, taking for granted that the reports that he has heard concerning the enormous profits to be derived from the work proposed are true. He is willing to be contented with small profit, or none at all, in order to learn the business and is certain that the reason for his bid being so much lower than any other is that the other fellow is expecting enormous profit. The engineer knows, however, that with an inexperienced contractor he can not get the class of work he desires, no matter how many competent inspectors are employed. As soon as the work gets well under way the contractor begins to realize that he is bound to lose money, and then comes the "battle royal." Every clause in the specifications is scrutinized and every contention possible is raised. The invariable result is a spirit of getting as good work as possible, get through, and forget it.

To approve a bid other than the lowest is more difficult on public work than on work being done for private interests. We all know how reasonable and fair the public is to its officials(?). If a contract is let to any other than the lowest bidder the public *knows* that something is wrong—some one is getting something he is not entitled to.

"LIQUIDATED DAMAGES."

When a contract is let to an inexperienced contractor, the usual result is that he fails to complete the work within the specified time limit. Now comes our old friend, "liquidated damages." We all camouflage by stating that the sum mentioned in the specifications is not to be construed as meaning a penalty but as liquidated damages. How many of you have ever seen this clause enforced? We all know that during the time the work is being done that one can always find countless reasons why the work was delayed. No matter who was to blame, the average man is willing to believe the contractor's statement concerning the causes for the delay. Attorneys seem to disagree as to whether you can compel a contractor to pay a sum of money for not completing a piece of work within the time specified. The courts are not inclined to look with favor upon fixing a penalty for nonperformance. The use of the words "liquidated damages" does not remove the difficulty; if the court thinks that in fact the sum stated (or any provision named) is in effect a penalty, it will refuse to sustain it.

There are two cases where "liquidated damages" seem to meet the approval of the courts. First, where the parties to a contract have in advance computed, ascertained, and agreed upon a sum as "liquidated damages." Second, where the amount of damage can not be definitely determined and a sum is fixed and stated as "liquidated damages." In this second case, however, the sum so fixed must appear to the court to be reasonable; otherwise the court will regard it as a penalty. The question in my mind, then, is how to arrive at the amount of the damage. To me it is rather intangible, especially so in highway work. We know that if the road is not finished that it is more or less of a damage to the public, but how much is the damage? You may suggest that the engineer compute the damage, state the amount in the specifications, and when the contract is awarded the signing of the contract settles the question. But does it settle the question? In construction contracts where blank forms are provided for a number of bidders, it can hardly be maintained that the parties have beforehand computed and ascertained the damage. Does it not more often mean that the contractor has entered into the agreement, "for better or for worse," trusting that he will be able to finish the work on time, and if not, expecting to have reasons to show that the time should be extended, or be able to prove that the amount stipulated is excessive and should be construed as a penalty? It is noticeable that this problem will generally occur when the contract has been let to inexperienced or irresponsible contractors, and this again emphasizes the fact that more attention should be given to the award of the contract. If the contract has been awarded to a reputable contractor, 90 per cent of the difficulties have been eliminated, because the contractor knows what to do and how to do it. He knows that the sooner he can complete the work the more profit he can expect, besides gaining a reputation which will be valuable in the future. Again, we all know how much easier it is to adjust differences of opinion regarding the specifications if the work is going along nicely and every one satisfied with the class and progress of the work.

COST-PLUS FORM OF CONTRACT.

Having given you my ideas concerning the unit-price form of contract, I will now attempt to discuss a form of contract which seems to be considered by some authorities as the panacea for all construction ills, which is the cost-plus form of contract.

One of the principal arguments used in favor of this form of contract is that the purchaser assumes the risks which are thrown on the contractor by the unit-price form of contract. It would seem, then, that the inexperienced contractor is eliminated. It gives the purchaser the power to select the contractor on the basis of past efficiency, and to leave to him the carrying out of the work just as its design is left to the engineer. It is claimed that this can be safely done in spite of the percentage form of contract, because, should the contractor fail in point of cost, time, or quality to meet the requirements of the work, he would injure his reputation and diminish his changes of obtaining future business and his ability to secure higher returns. From the above we may assume that contractors will be compelled to apply for work in much the same manner that engineers apply for positions. Going a step further we may expect agencies to come into existence whose work will be to list and classify contractors in order that it may be possible to secure the proper type of contractor for the work contemplated.

Just why it is assumed that a contractor will take more interest in the work, perfect a more efficient organization, and do the work for a smaller cost if the purchaser and not himself pays the bills, is difficult for me to understand. I remember one cost-plus job, on which I happened to be a member of the engineering staff, the contract of which provided that the contractor furnish certain power equipment, the cost of maintenance being borne by the purchaser. Shortly after the work started it seemed that every boiler of the work had flue trouble, which spread over the work until everything and everybody seemed to be afflicted with the "flu."

DEPENDENCE ON CONTRACTOR.

I am convinced that, for this type of contract to be successful, the purchaser must select a contractor in whom he can place perfect confidence and turn the job over to him. If the purchaser is doubtful as to whether he is being treated fairly and places a representative on the work to advise him concerning the expenditures of the contractor, endless friction will result. It might be suggested that the engineer in charge of the work be given the authority to act in this capacity, but I am not inclined to think this feasible. The engineer might act as auditor and be in position to say that the expenditures claimed were correct, but to give him the authority to say that whether or not the contractor shall make certain expenditures, or to pass on the question as to the number and salaries of employees, etc., is wrong. It is rather unusual to find two men whose ideas coincide in regard to the handling of construction work. Therefore, I say again, that the contractor must be given full authority to act as he deems best.

Now, we are confronted with the same problem as in the unit price form of contract which is the problem of knowing whether you have selected a contractor in whom you can place implicit confidence. I may have the wrong idea concerning human nature, but I am inclined to the belief that the average man puts forth his best efforts when the efforts affect his pocketbook. It is claimed that the contractor will use every effort to keep the cost down in order that he may build up a reputation which will enable him to secure further business. This may be true if inexperienced or irresponsible contractors are employed on this form of contract that some one will have to pay the cost.

Permit me again to say that the solution of contract trouble lies primarily in the selection of the contractor. I am certain that if funds are available to allow a cost which will give a responsible contractor a fair return, and if our laws will permit public officials to select the contractor, I would be willing to accept either type of contract. I feel, however, that before public sentiment will favor public officials being given the authority to select the contractor, that an educational campaign will need to be conducted. At the present time it will be charged that this system invites various abuses and we know there are many legal difficulties in the way of adopting such a system on public work, besides the great political difficulty of obtaining as good management by Government bodies which supervise construction work as there is by private ownership; and until the public has been educated as to the value of this form of contract and is willing to put such responsibility on its officials, "excuse me."

Utilizing More Mechanical Devices in Highway Construction and Maintenance

FRANK F. ROGERS, State Highway Commissioner of Michigan.

THE COST of materials and labor entering into road construction has advanced to such high figures that in many localities it has been a question of attempting to save in the cost of labor or practically discontinue road building. In Michigan the sentiment for good roads is so great that it would have been impossible for the State highway commissioner to stop road building entirely during the war period, even if he had attempted to do so. In fact there never was so much money available for road-building purposes in Michigan as during the past year.

During the fiscal year ended June 30, 1918, only 783 miles of State reward roads were approved, showing a slow-down over the previous year of approximately 25 per cent. However, the first five months of the present fiscal year ending November 30 shows a total of 560 miles of road accepted, as compared with 391 miles during the same period of 1917 or a 43 per cent increase over the previous year, in spite of all the war-time handicaps.

Indeed some peculiar economic conditions have manifested themselves. In most localities in Michigan there was a surplus of team labor and a great dearth of manual labor. In one county the commissioners reported more available labor than during any of the past three years. This was attributed to the fact that many retired farmers who heretofore had ample incomes from their farms, now, due to the high cost of living, found it necessary to supplement their farm incomes with more or less manual labor. These men were all past middle age and the inducement of very high wages for manual labor, from 35 to 50 cents an hour, doubtless had some influence in inducing them to become day laborers.

I do not know that anything new or startling has been used in Michigan by way of labor-saving mechanical devices but a few things are worthy of note.

TRACTOR IN GRADING AND DITCHING.

In grading operations tractors have largely superseded horsepower. Tractors were not only used for hauling blade graders but ditching has been successfully done with the Ford tractor and flat board scrapers. A scraper was hitched to each end of the tractor, which has a very short wheel base. The tractor then was moved across the road alternately forward and backward, but with a slight angle to the center line of the road so as to "cut over" the width of the scraper with each move. As the tractor moves ahead the scraper hitched to the rear end draws a full load up onto the road grade while the scraper hitched to the front end is backed to the ditch and vice versa. This way of using the tractor is said to be much more rapid than the work of two teams.

Grading has also been done with the same type of scraper by using a small gasoline reversible hoist placed on a truck stationed in the center of the road grade. A scraper was hitched to each end of the cable, the center of which was wound on the drum so that as one scraper was drawn out of the ditch with a full load the other was released and backed to the ditch and vice versa. This method of grading has also been quite satisfactory.

Steam shovels have been used quite extensively in road grading, not only where the excavation is heavy but sometimes on rather light work where not more than a foot or even less had to be scalped off from the old grade.

DELIVERY BY MECHANICAL POWER.

Mechanical power for delivering materials to the roads has been used quite extensively and ranges from the motor truck to the industrial railway. In fact it may be said that mechanical hauling has very largely displaced team hauling on Michigan roads. I have in mind one case where a motor truck is making five trips with three yard loads of gravel on a haul so long that teams working on the same job make only two trips with two-yard loads, the truck delivering 15 yards as compared with four yards for each team. It should be remembered, however, that truck hauling is not a success on heavy grades nor in loose sand or deep mud.

The industrial railway has been used very successfully on long hauls and on light grades. Wayne County and Delta County and some contractors have used the industrial railway with much success.

Mr. L. E. Adams, county highway engineer of Alger County, Munising, Mich., reports: "We have been using the motor truck for the transportation of materials along the highway in the construction of macadam roads for the past four years and find a great saving in cost over team labor. The cost of truck hauling is less than one-half the cost of team hauling. We like the 4-wheel drive truck for dragging earth and gravel roads and for general maintenance work. The heavy 5-ton trucks are used only on construction work, for they move much slower than the lighter truck."

Mr. K. I. Sawyer, county road engineer of Marquette County, Ishpeming, Mich., reports: "Our road grading has been done the past season using a Fordson tractor to haul the road machinery. This substituted one man and the machine for two or three teams. It is impossible to make a cut equivalent to three teams, or for that matter hardly equivalent to what two teams would do, but the speed of the work is such that by making lighter cuts and more of them work equivalent to a three-team grader outfit has been accomplished.

"One of our drag men also uses a Fordson tractor in his dragging operations. I am not satisfied as to the advisability of this, for where there is a crust on the road, as in sand-clay construction, the question arises as to whether the lugs on the wheels do not do as much damage as the dragging does good.

CUTTING DOWN COST BY MACHINERY.

"The county operates one surfacing truck which is driven by the maintenance superintendent. This enables him to cover all his work and at the same time deliver the necessary supplies and small equipment from our warehouse to the various maintenance and construction jobs.

"In our surfacing operations in 1916 we employed 17 men and 5 teams, including roller men, foreman, and cook. The past year we employed a maximum force of eight men, including foreman and roller men, and one team and laid approximately double the amount of stone on longer hauls.

"The machinery used on this job was one hand pump; a 6-horsepower Fairbanks gas engine; a 250-gallon Morse centrifugal pump, both mounted on one set of skids and belt connected. The same apparatus was used for pumping water for sprinklers and pumping bitumen from tank cars into the tank wagons. A motor truck also was substituted for four teams. An endless belt conveyor of the grain type without buckets was used for unloading the stone cars. This took the place of six men while the spreading apparatus on the truck cut down the necessary spreading crew. The roller crew remained the same, but because of better watering conditions one sprinkler with a team proved all that was necessary except on long hauls or in exceedingly dry weather. When water had to be pumped by hand two teams and two extra men were required for the same work. I might add that we resorted to winter hauling on a considerable portion of our gravel surfacing work in order to cut down the cost, and I am nearly convinced that winter hauling with team and spreader will compare favorably with motor-truck hauling in summer."

EFFICIENT CONSTRUCTION PLANT.

The R. D. Baker Co., of Detroit, on the North Saginaw Road in Genesee County, in laying 10½ miles of 18-foot reinforced concrete on a 30-foot roadbed, costing $270,000, developed a construction plant where the aggregates were dumped from cars and motor trucks into a power loader, elevated to storage bins, loaded into 1½-cubic-yard dump cars, hauled in trains on a portable 30-inch gauge track by a motor engine to the concrete mixer, where the cars were hauled up an incline track by cable and the aggregates dumped into a segmental revolving drum, each segment containing one "charge" of coarse aggregate and one "charge" of fine aggregate, which was automatically measured and dumped into the charging hopper of the mixer. The Portland cement in bulk was loaded into a covered car, transported and elevated in the same way, from which it was measured in a swinging dump box and dumped into the charging hopper immediately following the aggregate.

This plant reduced labor to a minimum and made it easier, while the aggregates were kept clean and the subgrade perfectly maintained.

C. F. Winkler, county road engineer of Gogebic County, writing regarding road maintenance, says: "The past summer I had built two sets of car camps on wheels, two camps in a unit, a cook and sleeping camp. These, with two tractors, have maintained our road from Bessemer to the Iron County line, a distance of approximately 70 miles, as never before and at a saving of the cost of the tractors. In other words, I figure one summer's work will pay for the tractors.

"The camp car is, as all know, no innovation, but with tractors a move can be made every day, if necessary, thus keeping the crew within easy working distance of the job; hence the economy of this plan."

A NOVEL CONCRETE ROLLER.

J. W. White, county highway engineer of Monroe County, Monroe, Mich., reports the use of a novel concrete roller as follows:

"Our first concrete roller was a small one made of 2-inch plank 3 feet in diameter and 15½ feet long and weighed 2,200 pounds. This roller had a tendency to make the concrete wavy, which was attributed to the small diameter, so we had a larger one constructed with a diameter of 5 feet and weighing only 2,000 pounds. The surface of both rollers was concave so as to give the required crown to the roadbed.

"We find that rolling compresses a 5-inch slab of concrete between a quarter and three-eighths of an inch. We have rolled 10 miles during the season just closed, and if the above statement is correct on the basis of one-fourth inch compression, we have squeezed 657 cubic yards of voids and water out of the 5-inch slab. This statement sounds rather large, but seems to be backed by facts.

"The larger roller is made of steel and cost a little over $400. It has not added one dollar to the construction cost of the road other than the initial cost of the roller, and our experience would indicate that one roller could be depended upon to roll several hundred miles of concrete without wearing out.

"The surface of the rolled slab is as true as the average concrete road surface. The roller picks up the mortar just enough to leave a pebbled effect, which forms an ideal base for the asphalt top.

"In the finishing operation we have a templet which rides on the forms and is dragged ahead by the mixer. When 15 or 20 feet of concrete have been spread the roller is rolled back and forth an average of three times.

"The size of the roller gives it the appearance of being very cumbersome but it is easily rolled by hand by the two men whose duty it has been to put the finishing touch on the slab.

"We have constructed approximately 40 miles of concrete road in Monroe County in the last three years and until we hit on the idea of rolling to get a well compacted concrete our work was in spots very unsatisfactory."

GRAVEL BY SLUICING AND WASHING.

Alex. McKay, county road engineer of Calhoun County, explains a method of obtaining road gravel by sluicing and washing as follows:

"The washing plant is now at its fourth location. I have no definite data regarding the first two sets, as to amount of material moved to secure the gravel. On the first location we were able to secure an average of 100 yards per day for most of the time, but the later sets have been in more difficult situations.

"At the third set north of Bedford, work began March 19, 1918, and ended August 31, 1918. The prospect was so poor that we located at that point only after every other prospect had been investigated and we had spent over $100 digging into every hill and running down many reports within a radius of three miles. The pit was cross-sectioned before and after working, thus the figures as to yardage moved are quite accurate. All the gravel was hauled by the yard so we have another check on the total amount of material secured.

"The largest day's run was 44 yards and the smallest 15 yards. Men employed were: Foreman at $5, engineer at $3.50, hoseman and general helper each at $3. About 28 gallons of kerosene were used each day in two engines. A 15 horsepower engine ran a 3-inch centrifugal pump, giving approximately 250 gallons per minute at about 20 pound pressure at the nozzle through 500 feet of 6-inch spiral pipe. A 6 horsepower engine was used to run a revolving screen and elevator. A bar 'grisley' on top of bins removed oversize stone. Water was secured from a nearby creek. Our fine screen was a square mesh of $\frac{1}{16}$-inch opening, but there was very little fine sand carried over.

Total days worked (10 hours each)	131
Total yards gravel secured	3,200
Average daily yardage	25
Average daily cost of operations	$19.16
Total cost of operation	$2,511.81
Total yards moved from pit	10,500
Average cost per yard in bin	$0.78

"After getting all the available gravel in that location we moved the plant to the fourth or its present location, 1½ miles farther from the road. This pit was much more stoney and required an additional man to fork stone away from the sluices. This pit had been worked two years before and abandoned on account of the large amount of oversize stone and number of sand packets.

Total cost of moving	$162.00
In operation from September 6 to November 15, total number of days worked, 10 hours each	56
Total yardage secured	2,036
Average cost per day	$21.00
Average yardage per day	36
Average cost per yard in bins	$0.59

"It will be noted that no depreciation of machinery is figured. The total plant cost is around $2,500. Our experience with washing gravel has been that we can work over a large amount of poor material and secure a good road building metal at reasonable cost. We can not compete with good pits located advantageously with this small portable outfit, unless due credit is given for the excellence of the material thus obtained."

I regret that lack of time has made it impossible for me to go into this subject more thoroughly for I have found it very interesting, although I presume that reports from other States as to mechanical devices used would be fully as interesting as anything I have been able to offer.

NEW JERSEY 1919 PROGRAM.

The State highway department of New Jersey plans to build this year about 50 miles of the State highway system, at a total cost of about $1,980,851. The program adopted last July for this year's work was for the expenditure of $2,341,325, but it has been necessary to cut down the planned construction by the elimination of three sections because not over $2,000,000 is available.

In the work convicts will be used for a part of the roads. Prisoners from the State reformatory will be used to complete the road between Menlo Park and Rahway, while from the State prison labor will do the construction work on two other sections. Altogether about 75 from the reformatory and 225 convicts from the State prison will be employed.

MADE NAME OF AMERICAN SYMBOL OF COURAGE AND FORTITUDE.

Lieut. Harris E. Petree, a stenographer in the Bureau of Public Roads from June, 1915, to June 9, 1917, when he enlisted in the aviation service, was killed September 26, 1918, in combat with seven enemy scout planes behind the German lines. Details of his death, which have been received, te all story of remarkable courage. There is no brighter page than his in the history of the heroism shown in the American Expeditionary Forces.

Letters to his father, Frank Petree, of Oregon, Mo., from the commander of his squadron and from the Red Cross give details of his bravery. Lieut. Petree was at first reported missing in action. Lieut. Edw. J. O'Connor, commanding the 139th Aero Squadron, wrote December 23:

"Your son was last seen circling the aerodrome gaining altitude preparatory to joining a patrol of about 10 other machines. On this date we lost two other pilots from this patrol, who were forced to land behind the German lines and were made prisoners, and who have since returned to the squadron. They brought information from German sources that your son was brought down and was dead when found, with several bullet holes in his body, one of which had lodged in his head, undoubtedly causing instant death in mid-air, as the German report states further he came to earth with motor full on and the machine landed nose first.

"Lieut. Petree was a man loved by his brother officers and the enlisted men in the organization; very conscientious, he never failed to respond to the call of duty; he was an excellent pilot, and had he been spared I am sure he would have been one of our most successful aviators, and the final German reports indicate he did not die without a struggle, but on the other hand fought his adversaries to the last.

"It is some consolation to a parent to know that such a son willingly and unselfishly pursued his ideals to the hazardous extent necessary of a pursuit pilot, and gave his all to our country and its great cause."

The Director of the Bureau of Communications of the Red Cross, W. R. Castle, jr., wrote January 22:

"We are sending you some details of your son's death, and we can only tell you how proud we are to have the honor of being the bearers of such tidings. Our Paris office has cabled us, under date of January 18:

> "'Aviator Merrian Cooper, with assistance of the Red Cross, visited the region and reports the following: Lieut. Harris E. Petree, Pilot, 139th Aero Squadron, was killed September 26. He is buried in Cemetery de Lut, southeast Longuyon. He was killed in a combat of one hour against seven enemy scout planes. He had several opportunities to escape but returned again and again. Is hero of the village, made the name of American symbol of courage and fortitude.'

"Among all the accounts of the bravery of our young aviators which have come to us, this is the most glorious, and to you, who have paid the price of the sacrifice, we pay all honor."

Preparation for the Reconstruction Period Following the End of the War

S. E. BRADT, Superintendent of Highways, Illinois.

AT THE time this topic was assigned to me after-war conditions were largely a matter of speculation and even to-day with the war won there is still but little indication of what those conditions are to be. For the purpose of reaching a fair conclusion as to these problems we have consulted the heads of economic departments of at least 10 of the universities of this country, and also the State and Federal departments of labor. In addition to this we have had access to the reports of the leading statistical organizations, as well as to the magazine writers of this country and of England.

In the war just closed the men actually engaged are counted by the millions as compared to hundreds of thousands in any previous war. Money has been expended by the hundred billions as compared to the hundred millions heretofore. The disturbance of normal conditions has been in proportion to the men and money involved. Hence the task of readjustment is correspondingly greater than that following previous wars.

We mobilized in the United States for the Army and Navy approximately 4,500,000 men. It has been estimated that it has required 4 civilians to each man in the army to provide food, clothing, and other war necessities, which would mean approximately 18,000,000 men in war work. Of the above number probably 3,000,000 of civilians are employed in war industries, the necessity for which ceased with the signing of the armistice. These men will be released from their present employment as rapidly as contracts can be legitimately canceled, and the war industries closed down. Adding to this 3,000,000 civilians approximately 3,000,000 soldiers and sailors, shortly to be released, we have a total of 6,000,000 people who must be returned to their old places or be given new ones. Those returning to their old places in many instances will displace others now filling them. The reabsorption of this vast number of men into our industrial life is the main problem that now confronts this Nation.

LABOR AND THE WAGE PROBLEM.

The two phases of this problem that more directly concern those in charge of highway work are:

1. Its probable influence upon wages.
2. Our duty to assist in this crisis through the employment of labor.

This condition of labor seeking employment undoubtedly presages among other things a readjustment of the wage scale. Indications are that this readjustment will be very gradual and that we may not for many years, if at all, reach the pre-war schedule. While the conditions following the Civil War may not be any guide in the present situation, yet it is of interest to know that wages from 1865 to 1870 made a gradual increase, while at the same time commodity prices gradually decreased. Wages are so much higher now than at the close of the Civil War and unemployment likely to be so much greater, that we do not look for a similar increase. On the other hand, while commodities are higher yet we must remember that we are now subject to a measure of government price control; and what is of greater import the war area is so much larger, involving a world shortage of foodstuffs, that very little if any decline can be expected until another harvest at least.

S. E. BRADT

With this situation confronting us shall we assume the attitude of holding our money awaiting a considerable decline in prices of labor and material, or shall we proceed to carry on a moderate amount of work with the idea of giving relief to our citizens, both through the improvement of the roads and the employment of those released from war work?

WAGE COST SHOULD NOT STOP WORK.

Personally, I am of the opinion that the immediate economic value of highway improvement is so great that we can afford to carry on this class of work, so long as its cost is not out of line with the cost of labor and commodities at the time the work is done. While the cost of improving the roads may have increased from 60 per cent to 75 per cent, the value of the commodities being hauled over the roads has in many instances increased over 100 per cent. The farmer can afford to give the same number of bushels of wheat for the improvement of roads over which to market his crops when wheat is worth $2 per bushel as he could when wheat was worth $1 per bushel. Likewise, the owner of an automobile or motor truck can afford to pay a higher price now for a 365-day road when gasoline and tires and repairs are high than he could a few years ago when these automobile essentials were much lower. The fact is that the cost of roads to-day, measured not by dollars but by the things we produce on our farms and in our factories and the selling price of labor, is no greater to-day than it was three years ago.

PUBLIC WORK SHOULD BE RUSHED.

Again, from the standpoint of assisting in the employment of labor during this crisis, it is undoubtedly the duty of the State to do what it can to tide over this period of uncertainty and unrest. This problem of the unemployed is not alone the problem of the United States; it is the problem of every country that has been involved in this world-wide war. Right Hon. Arthur Henderson, member of Parliament, says: "Many urgently needed public works will have to be taken instantly in hand by the Government, such as the building of houses, the making and improving of roads, railroads, canals, and the reclamation of land." Prof. Harold C. Moulton, of the United States War Labor Policies Board, says that all public and semipublic works which have been held up by the war, or for which a need has become apparent since the war began, should be pushed now with the greatest possible speed to reduce unemployment to the minimum. He refers especially to the improvement of roads by State governments and to the resumption of street and public utility improvements by municipalities.

President Wilson, in a recent letter, addressed to Secretary of Agriculture Houston, urges that the Government resume in full measure the highway construction operations under the Federal-aid road act, and to do so as speedily as possible. Further, that additional appropriations be made available in order that this work may be extended. It would then be in the line of our duty as highway officials to make all preparation possible for the early resumption of highway improvement. Our suggestion, however, would be that contracts be limited to the amount of work that can be completed within the season, with a clause providing for cancellation of contract at the option of the State if the work is not completed within the time specified.

ILLINOIS' BIG ROAD PROGRAM.

Undoubtedly Illinois has made the greatest financial preparation of any of the States for the after-the-war highway work. The fiftieth general assembly, which convened in January, 1917, passed a law providing for a referendum upon the question of issuing $60,000,000 in bonds for the improvement of a State-wide system of highways. This measure became a law in June, 1917, after the United States had entered into this world-wide conflict. It was generally conceded, both in and out of the legislature, that if the war was still on at election time its approval by the people was doubtful. Within a short time after the adjournment of the legislature Governor Lowden made public a statement to the effect that if the bond issue was passed by the people no bonds would be sold or construction begun until after the war. With this statement he forecast the probable situation at the close of the war, namely, a surplus of labor and a shortage of work, and urged the people to vote the bonds in order that Illinois might be prepared to do her part in giving employment to the returning soldiers and to civilians thrown out of work by reason of the closing of war industries. This phase of the question appealed to the people and was no doubt responsible for a goodly part of the large majority of votes given the bond issue at the election.

I have seen no estimate made by any competent authority as to the duration of the readjustment period and I shall not hazard a guess myself. However, I believe there is still time for other States t make financial preparation and still be able t assist in this readjustment work.

$700,000,000 FOR HIGHWAY WORK.

From answers received to inquiries sent to al State highway departments it appears that there will be available for highway work during the ensuing two years approximately $700,000,000, involving the employment of approximately 400,000 men each year for the working season, estimated a 180 days. Undoubtedly the amount available an included in this sum will be materially increased b many of the States.

In connection with preparation for highway wor we would urge return to normal conditions throug the release of control of highway bond issues by th Capital Issues Committee. It is apparent that if th proceeds of these bonds is to be made available at a early date to assist in preventing unemployment, the various political units which are entitled to issue them should be permitted to proceed without further delay. I believe this to be a proper matter to receive the attention of this association.

There is another condition brought about by the war which has added materially to the cost of roads, viz, the matter of freight rates. Prior to the time of utilities commissions and the Interstate Commerce Commission many States were given concessions in freight rates on road-building material. These have not only been annulled, but the rates on this material have been increased in some instances out of proportion to advances on other commodities. I believe that some relief should be obtained, especially during this emergency.

Still another line in which preparation should be made is in the matter of engineers. More than two-thirds of the Illinois force are now engaged in Government service. The colleges can not supply the demand. It is, therefore, desirable that some concerted action be taken with a view to having these men now in Government service released as rapidly as possible to make preparation for home enterprises.

Our greatest railway development in the United States covered a period of about 12 years, following closely the end of the Civil War. This was brought about to some extent at least through the settlement upon the lands of many of the returned soldiers. The soldiers who have been in France and Belgium and Italy and have seen the government roads of those countries, reaching to the smallest hamlets, will not be satisfied with conditions in our agricultural sections until we, too, have a system of roads fairly comparable to those on the Continent. If we expect those boys to return to the farms from which they came or to the farms in new sections we must prepare the way by a system of roads that will connect them not only with their adjacent communities but with the country as a whole.

Engineering Treatment of Necessary Railroad Grade Crossings

RODMAN WILEY, Commissioner of Public Roads of Kentucky.

THE subject assigned me is of such a specific nature that I beg leave to depart somewhat from the text in order to discuss a little more freely grade crossings in general. I shall use in its broadest sense the term engineering.

I appreciate the fact that I am attempting to discuss a complex problem and realize that any suggestions made will perhaps be radical, and most likely impracticable, but I am contented with the effort if a discussion of the problem will bring forth other ideas which have as an aim more cooperation between railroad companies and the people, which will result in a reduction of the loss of human lives.

When travel was mostly by steel-tired vehicles, the danger at crossings was at a minimum, and naturally the question did not receive, and was not expected to receive, the consideration it does to-day when most men are endeavoring to save time and make money, and the majority of the travel is by automobile and automobile truck. In order to take care of this new method of travel the highways are now carefully planned, particular care is being taken to see that the proper type of surfacing is used, wide, strong and expensive types of bridges are being built, but the grade crossings are receiving practically no attention.

PROTECT CROSSINGS TO SAVE LIFE.

A chain is no stronger than its weakest link, and naturally one would suppose that inasmuch as we build safe roads and safe bridges to prevent loss of life and materials so should grade crossings be properly protected for the same reason.

It is believed that some railroad companies and the public in general have failed to appreciate the act that the highways are one of the great systems of transportation and entitled to the same consideration as that given other transportation systems.

It has been customary for some years when one railroad crossed another railroad company's track for the one desiring the crossing to not only receive permission from its senior but to furnish the necessary frogs and install all interlocking signals. The same is true when interurban lines cross railroad tracks.

We know it is impossible to span a navigable stream with either a highway or railroad bridge without first receiving a permit from the Federal Government. The Government specifies the length of span and the height the bridge must be placed above low water; in other words, the Government appreciates the fact that neither of the other two systems of transportation shall interfere with the safe passage of boats. Yet until very recently it was known to be almost an unheard of thing for highway officials to be consulted when a road was to be crossed by either railroad, interurban, or street car lines. In many instances such has been done without even installing danger signals.

THERE IS LACK OF ATTENTION.

In the majority of cases crossings are treated the same to-day as 10 years ago, and it appears that the principal cause of the trouble has been the lack of attention not only on the part of the officials but on the part of the people, which naturally implies the lack of engineering advice.

Statistics show that the railroad companies pay out considerable sums of money because of accidents and deaths at grade crossings. Naturally such corporations endeavoring to reduce their expenditures to a minimum, and especially to save human lives, have installed all sorts of safety devices, a great many of which are absolutely ignored by the public. We now find stationary electric bells in some cases, swinging electric bells in others, electric lights, and finally at the most important places we see gates and watchmen.

Considered from a purely financial standpoint very few railroad crossings are properly maintained, so that a machine is damaged each time it passes over one. Suppose that the damage to a machine amounts to only one cent and that a hundred machines pass that crossing in a day. That means that damage has been done to the extent of one dollar per day, $360 per year, which is the interest on $6,000.

I take it that necessary grade crossings are made so because of great difficulties which would be encountered in eliminating them. Such things as the topography of the country, rights-of-way trouble, damage to property and, in its final analysis, lack of funds, because certainly the majority of crossings are unnecessary provided the money is available to eliminate them.

It makes no difference what is suggested there will always be accidents so long as we have grade crossings, and anything that is done is merely an insurance against death or accident, and the first question would most naturally be, who should pay the bills? We find that when either a highway or railroad company crosses a river, which is navigable, it pays the bills, and when one railroad company crosses another the junior company pays the bills. The same is true of interurban lines crossing railroad tracks.

PUBLIC SHOULD PAY PART OF COST.

One might naturally think that the railroad grade crossing question should be handled in the same manner. The railroad company, however, being a corporation, is liable for damages and should and perhaps would in most cases be willing to pay part of the cost, even though it might have priority claim at the crossing. But certainly if the people are determined to travel at a greater rate of speed, so that their lives are more in danger than they have been in the past when most grade crossings were allowed to come into existence, and especially when human nature and human carelessness enter so much into the proposition, the public should pay some part of the cost. It should be remembered that the people, not the railroads, have changed their method of travel.

No two men behave exactly in the same manner when crossing a railroad track. A few will stop and listen for approaching trains, others will slow up their machines and look hurriedly to the right and left, but the majority will plunge headlong over the track without taking any precautions whatever. Certainly no concern should be penalized for the lack of attention paid to all warnings, especially when the railroad is a necessity and is rightfully allowed to exist under the laws of the country.

The highest courts in many of our States have refused to give judgment against railroad companies because the drivers of automobiles have not exercised reasonable precautions in crossing railroad tracks.

It is a question of human life against money and I venture to say that very little will ever be done until the public appreciates the value of a human life. All sorts of excuses will be given and accepted, because in order to properly protect their own lives and the lives of their fellow men the people would have to pay a little more taxes.

SAFETY MEASURES RECOMMENDED.

Some engineers after carefully studying the question have recommended that the highway on each side of the railroad track should be made straight and level for some distance back of the track. That, of course, is a great precaution, and would tend not only to prevent accidents from collisions with trains but it would also tend to prevent accidents on the highways, as sufficient sight distance would be provided. Others recommend all sorts of electrical devices and interlocking signals to warn men that a train is within a certain distance of the crossing.

All electrical devices, however, are liable to get out of repair, and might not in isolated districts receive attention for many days. In such cases no warning would be given in the interim, so we can not depend entirely upon such things.

Because most accidents are due to the speed at which automobiles are driven, there should be a national law preventing any manufacturer under heavy penalty from making any pleasure automobile that can attain a greater speed than 30 miles per hour, and then every driver can keep his car under control.

Considerable danger could be removed if a great many of the roads were relocated and that could be done in a great many instances. Where a road parallels a railroad for some distance before crossing, the road should, if possible, be at least 300 feet from the track and the crossing should, if feasible, be made at right angles to the track. In addition, all obstructions to the view should be removed so that when a man makes the turn preparatory to crossing the track he can see both ways up and down the railroad for some distance.

BUILD ROAD PARALLEL TO TRACK.

As an added precaution, it would be well to build a road parallel to the railroad track for a distance of perhaps 300 feet each side of the main road, and, in all probability, it should be on the railroad company's right of way. The surface of the road should be at the same elevation as the top of the rails; in case a man saw he could not clear the track, or in other words that he was caught, he could turn, either to the right or left, off the main highway and run his car parallel to the track and prevent a collision.

Of course such things as electric lights, electric bells, etc., should be used in all cases because they always serve as a good warning.

Important crossings should be well paved, the paving to be level with the top of the rails so as to prevent a man killing his engine on the track; also to save the wear and tear on vehicles.

Less important crossings could be paved with timber, say 2 inches thick, set on edge, sized so as to make it level with the top of the rails, the timber to be nailed to the ties and to each other and all points of contact to be tarred. This would make a rather inexpensive improvement and it is believed the results would be admirable, as 2 by 4's spiked together and tarred have been used very successfully as flooring for bridges in Kentucky.

As a general proposition it would be well, as has been advocated, to make the road straight and level with the top of the track for a distance of at least 300 feet each side of the center line of the railroad and to have all obstructions, such as brush, high banks, etc., removed, so that a man can see both up and down the track when traveling any part of the 600 feet.

In as much as crossings might be divided into several classes according to their hazardous nature and volume of traffic passing over them, it might be well for representatives of the railroad companies in the various states to meet with the proper highway officials, take a census of all crossings, and divide them into classes. At the most hazardous or otherwise important crossings, from a standpoint of travel, in addition to doing all that has been said, it might be well to have gates and watchmen.

PRECAUTIONS BY THE DRIVER.

Sufficient precaution should be taken either in the way of making such changes as have been advocated, or else the driver of a vehicle should be required to stop and himself or one of the occupants of the vehicle be required to walk across the track before attempting to drive across.

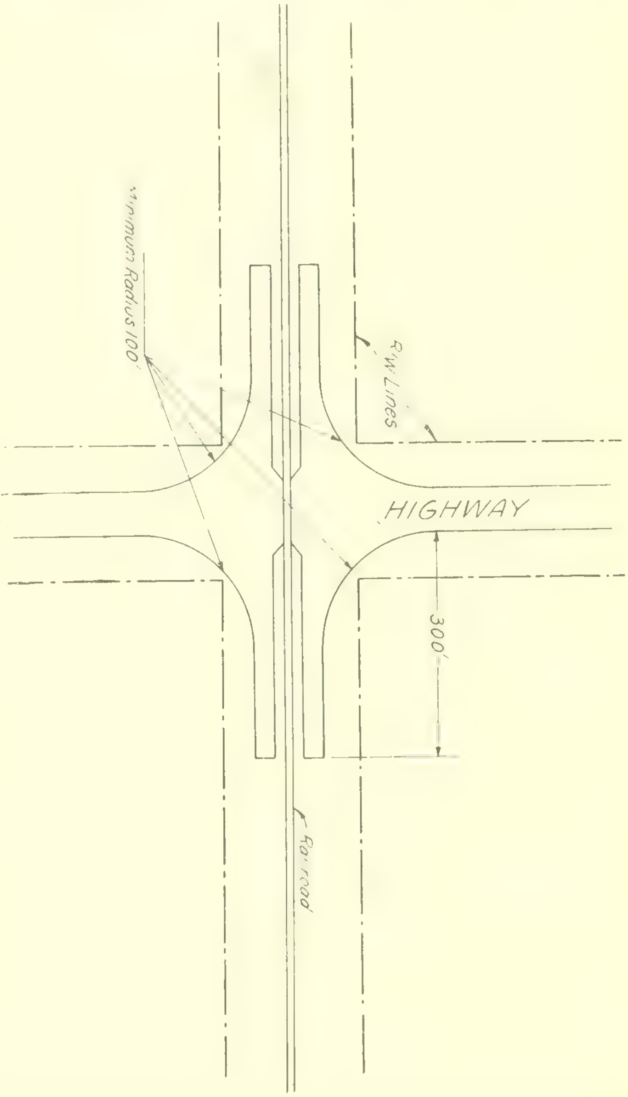
A street intersection in a busy town might be considered a necessary grade crossing. It is not, of course, in all cases a railroad crossing, but is subjected to a great volume of traffic. We find that soon after the advent of the automobile the police departments in practically all towns had watchmen stationed at the intersections to take care of the traffic.

An examination of the practice of street car companies and interurban companies in crossing the railroads shows that almost invariably the street cars or the interurban cars are required to stop on one side of the track, the conductor crosses the railroad track and signals the car ahead.

I know that complaints would be made by the autoists because of the time required to stop their machines and walk across the tracks. But when a man attempts a journey in an autumobile he is aware of the fact that he will, in all probability, have punctures and blow-outs and he is willing to take his chances in order to save time, and travel when it suits his convenience, and certainly if he is willing to repair two or three punctures in the course of a journey in order to go as he pleases, he should not complain if a few minutes of his time are taken up endeavoring to save his life.

The public should appreciate the fact that no precaution on the part of any railroad company will save a man's life if he is determined to be a fool.

Men know that insurance is a good thing, but oftentimes it is neglected and they die and leave their families penniless. They also know that tuberculosis is usually fatal, but the warnings of a doctor are unheeded and they die a wretched death, and so with railroad crossings. They are dangerous, always will be dangerous, it makes no difference what precautions are taken, and men will endure more danger in such cases because in order to safeguard their lives they will have to take a little more time and it might cost them a little money to eliminate the danger. All recommendations will amount to naught until it is appreciated that the highways are one of the great systems of transportation and entitled to the same consideration as other transportation systems, and until the people are ready and willing to place the roads under proper engineering supervision and act on the advice of engineers in everything connected with the system, and finally until the people appreciate the fact that the expenditure of most any sum of money is desirable if it prevents the loss of a single human life.



SKETCH SHOWING PLAN FOR SAFETY ROAD PARALLEL TO RAILROAD TRACK AT GRADE CROSSINGS

Railroad Car Shortage for Movement of Road Material and How to Meet it

CLINTON COWEN, State Highway Commissioner of Ohio.

THE colossal events that have been staged and acted in rapid succession since July, 1914, are too well known to require repetition.

The tottering and final collapse of the civil and military power of Russia, almost at the very time the United States entered the world's greatest conflict, were events sufficient to fill the minds of the thinking people of this country with a degree of apprehension that few were, at the time, willing to confess.

The rapid transition from civil to military conditions naturally resulted in much confusion. The administration of every official seemed to have a trend toward the policy of "safety first."

Thus it was we first felt in highway construction the blighting effect of car shortage.

The increased demand on railroad service on account of war activities must be apparent to all who are at all familiar with the necessities of the War Department for maintaining and supplying, not only our troops in all requirements of army service, but furnishing a substantial part of the requirements of our allied armies. But to this alone can not be laid the blame for the alleged car shortage. The development and maintenance of most railroad properties has not kept pace with the ordinary commercial development of the country, to say nothing of the abnormal increase due to the war.

TWO CAUSES OF CAR SHORTAGE.

A trip over almost any railroad running out of Columbus, Ohio, especially the roads running north and south connecting the coal mines with the Great Lakes, would have shown that the car shortage was due largely, if not entirely, to lack of motive power and proper terminal facilities. Had the terminal facilities and motive power been properly developed, I am of the opinion that there would not have been a serious curtailment of freight shipments for road construction.

But, dealing with a condition rather than a theory, the fact remains that shipments of road materials were in most cases irregular, uncertain, and very unsatisfactory. The above conditions were met and to a considerable extent overcome by consistent management in avoiding delays which formerly were traceable to the management of operations on the work. Formerly shippers were often notified by the superintendent in charge of construction to discontinue shipping until further notice, without apparent or sufficient reason, but during the car-shortage period, shipments were continued if possible, even at the expense of an extra handling of the material by storing it until ready for use. Another means of overcoming the difficulty was a wider use of local materials which were prepared for use by portable plants.

MOTOR TRUCK SOURCE OF RELIEF.

But the greatest source of relief was found in the use of the motor truck.

This instrument of modern mechanism that has wrought such havoc with many of our roads seems destined to become an indispensable means of transporting material in highway construction. One noticeable incident of this was in the construction of a concrete foundation for which the materials were shipped originally by rail to a point within two miles of the work. When freight shipments were suspended, not a day was lost before the contractor had in the service a small fleet of trucks hauling stone direct from the quarry some fifteen miles from the site of the improvement.

Another instance worthy of mention is where stone was hauled by rail about six miles to a point from which the average wagon haul to the road would be about a mile and a half. Terminal facilities became obstructed and it was necessary to resort to trucks, which was done, and the work was carried forward with surprising economy and rapidity. The elimination of one handling at the railroad, the ability to spread the stone almost perfectly by tilting the truck bed to proper angle and the general stabilizing effect on the work, enabling the contractor to use advantageously a greater gang of laborers, are some of the reasons why trucks may be used to an advantage on short hauls and even on moderately long hauls where roads are in condition for truck service. To the contractor, a direct haul from the quarry means the saving of the cost of loading, demurrage charges, and congested conditions that so often arise due to irregularity in railroad delivery.

A STIMULATION TO THE ENGINEER.

The condition brought about by car shortage was fruitful in stimulating the engineer to extend his resourcefulness in many new directions. The more extended use of local material and the easing off in requirements of high-grade material, especially where the construction is more or less in the nature of an emergency, were freely resorted to with gratifying success.

We are all well aware that the limits ordinarily fixed by engineers for the specification of materials do not necessarily mean that a reasonable departure under stress of emergency may not be justifiable. The extent of this departure, of course, must be governed by local conditions and possible results.

There need be no argument set forth that certain types of road when applied in a certain district will require much more transportation than will other types.

Almost immediately after the declaration of war by the United States, Camp Sherman was located at Chillicothe, Ohio, about 50 miles south of Columbus. The materials and supplies necessary for the construction of this great cantonment taxed to the limit every available means of transportation that could be provided. The city of Columbus, the capital of the State, with a population of more than 200,000, was naturally looked to as a source of supply not only for the camp construction, but for the supplies and equipment necessary to maintain this great army of from 40,000 to 50,000 men.

BUILT 33-MILE ROAD TO CAMP.

Although the camp and the city of Columbus are connected by railroad and trolley lines, every highway, direct or indirect, connecting these two points was used by the increased travel. Many influential people, prompted by patriotic duty or otherwise, became very much exercised in regard to our road conditions to the camp. The idea of constructing a brick road or concrete road or other high-type of improvement was strenuously advocated, which road, if the request made at the time had been acceded to, would no doubt have been under construction at the present time and perhaps far from being completed, with all the hardships of the detour incident to the construction of such roads.

Instead of pursuing this course, it was generally known that large supplies of good gravel existed at different places almost the entire length of the road to be improved, which was a link of 33 miles connecting improvements formerly made by the State highway department. The link as it existed was an old worn out macadam and gravel type of construction without drainage and with many places broken through to the clay. The deputy of maintenance prepared and submitted an approximate estimate of cost of a quick and economical but substantial improvement of this road with gravel. The estimate was about $3,300 a mile. This included all road drainage, widening of the shoulders and the surface of 16 feet of from 4 to 5 inches of water-bound gravel.

CLINTON COWEN

The work was undertaken and carried out, divided into a convenient number of sections, by force account under the immediate supervision of the deputy of maintenance. The total cost of the construction and of maintenance up to the present time is about $3,400 a mile. The exact cost of original construction can not be separated from the cost of maintenance because the maintenance commenced of course on portions of the road before the remainder had been completed. The whole work of constructing the 33 miles was finished in a period of about six months, and this was done without blocking the road against traffic and with very little inconvenience to the public. This was accomplished through the use of good bank gravel and motor-truck and horse-drawn wagons.

Immediately on the completion of this road the travel was so great that a double line of enormous passenger cars with a capacity of twenty-odd passengers was installed, making two round trips a day.

The work of maintenance is, of course, continuous, although not expensive, and on the whole, I regard this as one of the interesting pieces of work accomplished by the department, certainly one from which the public received immediate and large benefits.

I am stoutly of the opinion that where good gravel may be obtained and with the use of a motor truck, the construction and maintenance of rural highways in such localities should no longer be a serious problem.

MEETING DEMAND ON MOTOR ROUTES.

As a result of car shortage conditions in the country and the over-taxed capacity of railroads, enormous fleets of Army trucks, automobiles, and other trucks passed over certain roads, especially those running east and west, destined to Atlantic ports. Among the most important of these was a road running through the northern part of the State, connecting Chicago, Detroit, and other points west, with Toledo, Cleveland, and Pittsburgh. This road was so heavily traveled by traffic of this character that much damage was done to it on types of road of almost every character.

Our ability to maintain this road was only made possible through the use of truck service. The spring of 1918 taught us a lesson in regard to road construction, that many of the roads we had previously constructed were not adequate to such conditions and to even greater strains that might be required in the future.

In order to relieve the northern route through Ohio of part of its heavy traffic and to provide for truck service that was growing constantly, we decided to fill in some links yet unimproved on the National Road, passing east and west through central Ohio. There was yet unimproved and not yet under contract as late as March, 1918, a section of 14 miles in Muskingum County. This section was in such condition that it practically prohibited the use of a road that millions of dollars had been expended on because of this unimproved portion.

Adopting rather heroic measures and brushing some legal technicalities aside, in April of this year we entered upon the construction of this road, subdivided into convenient working sections, under a cost-plus basis contract. We rallied to our assistance every available means at our command. The Government, realizing the importance of this work, lent us such assistance through railroad service as congested and restricted conditions of traffic would permit. Prison labor, free labor, auto trucks, and horse-drawn wagons were used on each section.

With much of the force inexperienced and with organizations more or less imperfect as must obtain on work of this magnitude and under such conditions, the entire stretch of road was completed and opened for travel on October 22, 1918, a period of a little more than six months.

The type of road was brick with mastic filler, 16 feet wide, upon a 6-inch rolled sandstone base with 6-inch cement curbs. The grading was rather heavy. The estimated cost of the 14 miles was $488,500, which was prepared in January, 1918. The actual cost of construction is not yet fully determined but will exceed the estimate in the neighborhood of 20 per cent, which may be largely accounted for in the increased freight rates and the amount of material used in the construction of a cost-plus job over that in a similar job under a straight contract.

To the use of convict labor on this work may be credited a large measure of our success. Although such labor did not exceed possibly 33⅓ per cent, the stabilizing effect it had on free labor was no doubt the means of preventing more or less unsettled conditions.

The above are some of the important instances of car shortage and how we met them.

PROPOSES BIG IOWA BOND ISSUE.

A bill has been introduced in the Iowa Legislature providing for a system of 17 cross-State paved highways, to be paid for by a bond issue of $50,000,000. The bonds are to be paid for by a combination of district taxation and the use of the funds from State automobile licenses, and the highways are to be durable, hard-surfaced roads which will, in the judgment of the highway commission, remain in good condition with reasonably low maintenance cost until after the bonds have matured. Many of the highways are now well known cross-State roads. The bill would do away with the present State highway commission and create a new commission of three, appointed by the governor, to administer road affairs.

COLORADO HIGHWAY TRAFFIC.

The Colorado State Highway Commission has completed a road traffic table for 3,827.6 miles of road out of the 7,000 miles of State routes for the year 1918. The table for the year is based on reports for traffic for the month of August. Chief Engineer Maloney states that the traffic is conservatively stated, particularly in regard to wagon haul, as the records were not taken when much produce or grain was being moved. The figures show the year's traffic in ton-miles as follows: Automobiles, 115,539,888; trucks, 28,576,262; wagons, 13,696,238; total, 162,926,098. The average ton-mile per mile of road was 42,566.

INDIANA LAW CONSTITUTIONAL.

Indiana has not heretofore been able to take advantage of the Federal aid law because of the contest in its courts over the validity of the State law of 1917 which enabled it to do so. The lower court pronounced the law unconstitutional and there was to be an attempt in the session of the legislature this winter to repeal it and enact a new law to take its place. The State supreme court has now reversed the decision of the lower court and pronounced the 1917 law constitutional and all that was done by the State highway commission appointed by Gov. Goodrich in 1917 has therefore become validated. Some amendments to the law may be made this winter.

FEDERAL AID IN OCTOBER-NOVEMBER

AN OUTSTANDING feature of the record of Federal aid projects considered in both October and November, 1918, was that the number of projects which went to final agreement exceeded in number those approved. In October 28 projects were approved while final agreements were signed for 42. The figures for November were 26 and 43.

In October the projects approved or which went to final agreement called for a total of 471.526 miles of road, for which the Federal aid allowance was $1,615,310.03 on an estimated cost of $4,646,225.20. In November the mileage was 636.9623, the estimated cost of all projects $4,557,507.68 and the allowance, $1,847,893.09.

The largest allowance for a single project made in October was $120,627.20 for 24 miles of gravel road in Missouri, estimated to cost $241,254. Another Missouri project approved was for 11.2 miles of asphalt and brick, with an estimated cost of $384,853.26 and an allowance asked for $96,213.31.

The next largest allowance for a single project was $100,200 on 10.02 miles of concrete road in Maryland, a part of the Washington-Baltimore highway, the improvement of which is estimated to cost $237,449.96. This road during the past year carried an especially heavy military traffic, as well as an unusually large commercial traffic. Another road built because of special military use is 6.52 miles of concrete highway in Georgia, leading to Camp Gordon, estimated to cost $169,560.88, for which an allowance of $47,500 was made.

Ohio received the second largest total allowance in October, $160,800, for concrete, brick, or macadam roads, to cost $523,779.83. Five projects in Iowa put that State in the lead in the mileage, amounting to 55.07 miles of earth and gravel roads, estimated to cost $268,856.50 and a total allowance of $100,939.96.

Wisconsin led in October in the number of projects considered, 12, all final agreements, with a mileage of 52.556, a cost of $437,175.30 and an allowance of $129,031.76. West Virginia came next with 8 projects going to final agreement, estimated cost $344,111.75 and an allowance of $90,751.

In November Pennsylvania projects considered have a total estimated cost of $766,362.34 and an allowance of $181,580. The mileage was only 18.152, concrete, bituminous concrete, and brick. The largest allowance to any one State for the month was $202,999.32 to Oklahoma for 25 miles of concrete road, estimated to cost $205,998.77, and a bridge over the Canadian River, estimated to cost $223,115.27.

Four projects from North Dakota, of gravel and earth roads, gave that State the largest total mileage, 83.7, while two roads in Minnesota with an aggregate length of 51.15 miles put that State second. The largest number of projects from a single State considered was 7, from Virginia, with a mileage of of 21.897, and estimated cost of $193,510.38 and an allowance of $91,105.31.

Federal Aid Projects in October, 1918.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid allowed.
Alabama	23	Coffee	9.305	Sand-clay		Oct. 18	$23,304.35	$11,652.18
	32	Conecuh	6.81	do		Oct. 25	35,625.04	17,812.52
Florida	8	Alachua	11.67	Top soil	Oct. 22		33,680.28	16,840.14
Georgia	14	Floyd	7.75	Gravel or top soil	do		30,030.00	10,000.00
	27	Polk	14.70	do	Oct. 25		41,184.00	20,000.00
	40	Dekalb and Gwinnett	6.52	Concrete	Oct. 14	Oct. 24	169,560.88	47,500.00
Idaho	6	Idaho	21.77	4 mile macadam, 18 earth		Oct. 26	250,368.03	86,000.00
Iowa	24	Polk	7.75	Gravel	Oct. 18		67,721.50	23,041.07
	26	Adams	10.00	Earth	Oct. 8		47,795.00	16,507.60
	27	Appanoose	11.00	Graded earth	Oct. 7		46,750.00	19,832.33
	34	Keokuk	12.25	Earth	Oct. 9		45,100.00	22,345.19
	35	Chickasaw	13.07	Gravel	Oct. 22		61,490.00	19,213.70
Kansas	1	Mitchell	11.25	Concrete	Oct. 18		229,130.00	34,369.57
	16	Rice	3.00	Brick or concrete	Oct. 22		115,061.76	17,259.26
	17	Geary	.09	Brick	Oct. 21		39,947.16	9,000.00
Kentucky	9	Todd	2.45	Macadam	Oct. 18		23,428.00	11,714.00
Maryland	6	Prince George, Howard, Baltimore	10.02	Concrete		Oct. 19	237,449.96	100,200.00
Michigan	15	Livingston	4.232	Gravel		Oct. 31	[1] 44,555.98	22,277.99
Minnesota	15	Becker	19.96	do		Oct. 28	88,904.26	30,000.00
	34	McLeod	9.10	do	Oct. 26		33,333.94	15,000.00
Mississippi	11	Amite	6.92	do		Oct. 30	[1] 47,236.75	20,000.00
	36	Walthall	9.35	do	Oct. 18		63,129.00	30,000.00
Missouri	7	Mississippi	24.00	do	Oct. 14		241,254.00	120,627.10
	14	Buchanan	11.20	Asphaltic and brick	Oct. 7		384,853.26	96,213.31
Montana	13	Park	4.25	Gravel	Oct. 21		19,916.59	9,958.29
Nebraska	23	Burt and Washington	26.30	Earth	do		55,641.30	27,820.65
Nevada	9	Washoe	5.423	Concrete or bituminous	do		139,792.86	54,230.00
New Hampshire	12	Rockingham	1.75	Gravel		Oct. 24	12,358.94	6,179.47
	15	Merrimack	1.73	do		do	12,360.09	6,180.09
	16	Hillsborough	2.26	Modified asphalt surface		do	39,932.95	19,966.47
	17	Rockingham	1.29	Gravel		do	20,423.78	10,211.89
New Mexico	3	Santa Fe	9.32	do		Oct. 26	63,397.81	31,698.90
North Carolina	23	Burke	7.68	Top soil		Oct. 28	42,873.90	7,500.00
	29	Union	8.655	Top soil or gravel	Oct. 18		27,794.66	5,000.00
	30	Mecklenburg	6.304	Concrete or bituminous gravel.		Oct. 31	102,551.35	26,900.00
	32	Edgecombe	3.10	Sand-clay or gravel	Oct. 9		14,080.70	7,000.00
North Dakota	6	Eddy	5.46	Gravel and earth		Oct. 9	12,816.86	6,408.43
	8	do	9.29	Gravel		do	[1] 24,[illegible]06.57	11,767.59
Ohio	20	Richland	3.58	Brick or concrete	Oct. 10		143,017.87	30,000.00
	24	Madison	8.39	Concrete or asphalt	Oct. 8		284,000.00	83,900.00
	25	Highland	4.60	Macadam or concrete	do		96,761.96	46,900.00
Oregon	12	Yamhill	2.75	Macadam	Oct. 16		39,683.38	14,871.69
	13	Grant	7.40	Gravel	Oct. 19		145,051.50	72,525.75
South Carolina	8	Bamberg	12.17	Sand-clay		Oct. 16	23,922.38	10,771.14
Tennessee	5	Greene	2.64	Waterbound macadam		Oct. 24	38,321.91	19,160.95
Virginia	4	Pittsylvania	8.03	Top soil		Oct. 14	[1] 21,697.44	2,450.00
	13	Stafford and King George	6.932	Gravel		Oct. 30	59,263.28	29,631.64
	14	Augusta	4.012	Waterbound macadam		do	49,866.92	24,933.46

[1] Revision of previous agreement.

Federal Aid Projects in October, 1918—Continued.

State.	Project number	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid allowed.
West Virginia	4	Marion	2.40	Concrete		Oct. 26	$47,457.67	$13,000.00
	9	Jackson	0.977	do.		Oct. 8	20,200.00	9,770.00
	10	Mason	5.81	do.		Oct. 11	103,517.70	16,530.00
	13	Roane	1.00	do.		Oct. 19	13,552.00	6,776.00
	16	Barbour	3.24	Bituminous macadam		Oct. 16	33,334.00	8,075.00
	21	Lewis	.66	Brick or concrete		Oct. 11	20,000.00	6,600.00
	23	Kanawha	2.96	Asphaltic concrete		Oct. 5	69,971.48	20,000.00
	24	Preston	3.85	Bituminous macadam		Oct. 11	36,078.90	10,000.00
Wisconsin	14	Dunn	4.95	Graded earth		Oct. 28	15,043.53	5,014.51
	19	Price	6.84	do.		Oct. 22	16,775.20	5,585.06
	24	Jackson	2.18	Concrete		Oct. 11	44,980.28	14,993.43
	26	Wood	2.82	Gravel		do.	17,156.10	5,718.70
	27	Washburn and Barron	9.02	Graded earth		Oct. 26	31,061.24	10,353.74
	33	Fond du Lac	3.69	Concrete		Oct. 31	74,864.59	24,954.86
	39	Racine	0.93	do.		do.	23,929.17	7,956.39
	40	Sheboygan	2.41	Bituminous macadam		Oct. 28	25,907.57	8,635.86
	42	Rock	2.45	Concrete		Oct. 31	51,603.03	17,201.01
	43	Trempealeau	3.27	Graded earth		Oct. 11	17,121.51	5,707.17
	47	Richland	2.94	Earth		Oct. 28	23,793.59	7,931.20
	48	Monroe	11,056	do.		Oct. 31	44,939.49	14,979.83
Wyoming	22			Bridge	Oct. 16		24,310.00	12,155.00
Total			471.526				4,646,225.20	1,615,310.03

Federal Aid Projects in November, 1918.

State.	Project number	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid allowed.
Alabama	27	Lauderdale	4.00	Chert		Nov. 13	$33,936.43	$16,968.21
	38	Lawrence	7.38	Gravel	Nov. 13		34,067.82	17,033.91
Arkansas	20	Poinsett	6.05	do.		Nov. 30	59,885.65	29,942.82
	21	St. Francis	7.93	do.	Nov. 23		34,333.72	17,166.86
Florida	4	De Soto	3.05	Sand-clay		Nov. 20	66,005.98	30,000.00
	5	do.	2.50	Brick or asphaltic concrete		Nov. 2	46,879.17	20,000.00
	9	Holmes	5.11	Sand-clay	Nov. 7		22,254.11	11,127.05
Iowa	29	Wright	14.88	Gravel	Nov. 4		85,855.00	22,345.19
	31	Howard	10.50	do.	Nov. 1		51,425.00	18,092.65
Kansas	2	Labette	9.14	Gravel or macadam		Nov. 20	77,720.80	11,658.12
	18	Allen	1.00	Concrete	Nov. 30		32,015.15	4,702.27
	19	do.	1.25	Gravel or macadam	do.		41,048.67	6,157.30
Louisiana	14	Caldwell	10.00	Sand-clay and gravel		Nov. 30	44,614.02	20,000.00
	15	Avoyelles	5.41	Gravel	Nov. 30		59,036.57	25,000.00
	16	East Baton Rouge	4.90	do.	do.		35,913.90	17,956.95
	18	Caldwell	2.40	do.	do.		11,462.99	5,000.00
Michigan	23	Berrien	2.53	Macadam		Nov. 1	44,676.02	22,338.00
Minnesota	31	Wright	23.37	Graded and drained earth		Nov. 20	59,383.41	15,000.00
	32	Kandiyohi	27.78	Gravel		do.	58,545.43	25,000.00
Mississippi	10	Lincoln	6.875	do.		do.	38,619.21	19,300.00
	12	Scott	5.62	do.		Nov. 23	30,002.61	15,000.00
	15	Wilkinson	9.00	Clay, gravel		do.	50,096.28	25,000.00
	35	Pike	7.40	Gravel	Nov. 23		48,290.00	22,500.00
Missouri	1	Cole	26.39	do.		Nov. 30	141,776.67	35,444.17
Montana	2	Wibaux	7.00	do.	Nov. 7		21,631.28	10,815.64
	20	Missoula	7.00	do.	Nov. 4		21,985.26	10,992.63
	21	do.	7.00	do.	do.		21,995.60	10,997.80
Nebraska	21	Box Butte and Sheridan	15.00	do.	Nov. 23		63,813.20	31,906.60
Nevada	5	Elko	18.73	do.		Nov. 1	98,066.56	49,033.28
	6	White Pine	12.46	Gravel or macadam		Nov. 20	63,846.20	31,923.10
New Mexico	12	Chaves	16.70	do.		Nov. 23	127,508.62	63,754.31
New York	13	Chautauqua	7.04	Concrete	Nov. 25		140,800.00	70,400.00
	15	Otsego	5.07	Macadam	do.		101,400.00	50,700.00
North Carolina	24	Wake	4.24	Concrete		Nov. 13	67,760.00	25,000.00
	26	Davidson	12.88	Top soil or sand-clay		Nov. 23	22,856.68	10,000.00
	34	Wayne	.064	Bridge	Nov. 12		20,001.30	10,000.00
	38	Rockingham	10.928	Top soil	Nov. 30		47,000.00	12,100.00
North Dakota	3	Williams	30.50	Earth		Nov. 30	83,745.74	41,872.87
	10	Pierce	5.00	Gravel, sand, clay		Nov. 11	11,730.24	5,865.12
	15	Sargent	31.40	Earth		Nov. 13	54,384.08	27,192.04
	20	Wells	16.80	do.		do.	[1]26,495.98	13,247.99
Oklahoma	1	Cleveland and McClain	.3723	Bridge		Nov. 23	223,115.27	100,000.00
	2	McCurtain	25.00	Gravel		do.	205,998.77	102,999.38
Oregon	10	Baker	17.80	Earth	Nov. 18		71,235.45	28,117.73
Pennsylvania	15	Beaver	1.006	Concrete, bituminous, or reinforced concrete.		Nov. 4	47,573.45	10,060.00
	17	Dauphin, Lebanon, and Berks.	3.80	Concrete		Nov. 30	133,588.89	38,000.00
	18	Clarion	5.00	Brick	Nov. 30		220,000.00	50,000.00
	19	Montgomery and Bucks	8.352	Bituminous concrete	Nov. 25		365,200.00	83,520.00
South Carolina	17	Calhoun	.22	Sand-clay	Nov. 12		10,015.72	5,000.00
	18	Greenwood	7.29	Top soil		Nov. 20	19,997.98	9,988.99
Texas	12	McLennon	3.50	Bituminous gravel		Nov. 1	26,679.82	12,500.00
	20	Gregg	33.59	Gravel		do.	115,317.52	50,000.00
	23	Dallas	2.167			do.	14,985.44	7,000.00
	55	Camp	9.924	Gravel or macadam		do.	65,664.52	17,454.00
Utah	2	Weber	9.28	Macadam		Nov. 11	61,340.44	30,670.00
Virginia	10	James City and York	2.462	Concrete		Nov. 4	69,014.44	24,620.00
	12	Franklin	6.16	Top soil	Nov. 23		56,936.44	23,468.22
	16	Botecourt and Rockbridge	5.398	Waterbound macadam		Nov. 4	61,575.83	30,787.93
	18	King William, Gloucester, and Middlesex.	13.777	Graded and drained		Nov. 13	44,193.30	22,096.65
	19	Fauquier	5.04	Macadam		do.	64,437.05	32,218.54
	20	Southampton	8.31	Gravel	Nov. 23		67,902.34	33 951.34
	25	Surry and Prince George	4.05	Bituminous macadam	do.		37,265.05	18,632.52
Washington	7	Lincoln	8.29	Gravel and macadam		Nov. 20	72,266.04	36,133.02
West Virginia	18	Tyler	1.00	Concrete		Nov. 11	27,754.43	10,000.00
Wisconsin	13	Clark	8.81	Graded earth		Nov. 20	26,987.07	8,995.69
	36	Milwaukee	.78	Concrete		do.	21,473.68	7,157.89
	44	Juneau	11.905	Earth surface and sand-clay		do.	30,633.01	10,211.00
Wyoming	2	Albany	10.41	Earth		do.	10,321.63	5,160.81
	20	Sheridan	8.00	Concrete or asphaltic gravel		Nov. 14	183,188.75	85,944.50
Total			636.9623				4,557,507.68	1,847,893.09

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[1] Revision of previous agreement.

STATE HIGHWAY MANAGEMENT, CONTROL, AND PROCEDURE

By M. O. ELDRIDGE, Assistant in Road Economics; G. G. CLARK and A. L. LUEDKE, Engineer Economists of the Bureau of Public Roads.

IN foregoing numbers appeared chapters on State highway management, control, and procedure. In this number are presented the chapters on two States. Each one takes up the development and results of State participation and control of road work and the relation of State to local control; organization, personnel, duties and powers of State and local road officials; classification of State and local roads with particular reference to control and basis of payment, including methods of selection, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by the State and local officials over road construction and maintenance; sources of State and local funds, basis of allotment and apportionment of State funds, and the relation of State to local funds, and the amount available for road purposes during the latest calendar or fiscal year.

MASSACHUSETTS.

Development.—State participation in road work in Massachusetts is of early origin and State-wide in extent. The State now exercises practically complete control over the construction and maintenance of 12 per cent of the rural roads and contributes approximately 54 per cent of all rural road expenditures.

Between 1794 and 1826 about 1,000 miles of turnpike or toll roads were established. These roads proved unremunerative to the stockholders and unsatisfactory to the public, and were gradually abandoned and turned over to the municipalities. The last turnpike was abandoned in 1868. From that time until 1893, when the State Highway Department was first established, complete control over practically all roads outside of cities was exercised by town selectmen.

The new State law provided for a continuous commission of three and established the policy of State aid to towns and State control of a system of roads to be known as State highways. Massachusetts, therefore, deserves the credit of having originated and given form to the idea of establishing a system of State highways constructed and maintained largely through the aid and control of the State. The form of the Massachusetts State highway organization has not materially changed since it was first established, although certain minor changes in policy and duties have been added from time to time.

The State funds available for State aid and for State highway construction and maintenance have increased from about $300,000 a year, when the work first started, to approximately $3,900,000 per annum at present. From 1893 to 1917, inclusive, the State expenditures have amounted to approximately $25,500,000. Local funds not under State control, exclusive of cities, now amount to about $3,350,000 per annum. During 1917 the total State and local expenditure amounted to $9,494,802.

The State has 18,681 miles of rural public roads, of which about 8,900 miles, or 47.6 per cent, have been surfaced. Of the surfaced roads about 2,270 miles have been constructed and are now being maintained under State supervision.

ORGANIZATION.

The highway organization of the State and the relation existing between the State and local forces is shown herewith.

State.—At the head of the State highway department is the State highway commission consisting of three salaried members. The commission is a continuous body, one member being appointed each year by the Governor. The commissioners devote their entire time to the work, about one-half of which is occupied with road matters and the other half with the conduct of the automobile department. All technical and clerical employees of the department are appointed by the commission from the civil service eligible list, and all employees must be citizens of the United States.

All engineering and technical work of the department is under the control of the chief engineer. He is assisted by the first assistant engineer, who has immediate charge of the designing engineers, draftsmen, and field parties, and an assistant engineer who is in immediate charge of specifications, contracts, and special work. The State is divided into four divisions, with a division engineer in charge of each, they reporting to the chief engineer. The division engineers are directly responsible for construction and maintenance work in their respective divisions. Each division engineer has a deputy and a corps of assistants and resident engineers to look after the details of construction and maintenance on each job.

The secretary of the commission has charge of records, accounts, and the automobile department. Under the secretary is an assistant secretary, a recording secretary, and a chief clerk, by whom the accounts and records of the department are handled. There is also a chief clerk who has charge of the clerical force in the automobile department and a chief examiner who has charge of the investigators and examiners in that department. In this connection it should be stated that the commission registers all the motor vehicles in the State, licenses operators, and makes regulations for the operation of motor vehicles. It investigates automobile accidents and may suspend or revoke licenses for proper cause.

Local.—Each county has a board of county commissioners consisting of three members elected by qualified voters for terms of three years. Their authority over local roads is very limited. Upon petition and after due hearing, they have authority to order the layout of new roads or to improve existing roads, and to determine what part of the cost shall be paid by the city or town benefited. They also have authority over certain intercounty bridges and employ engineers when necessary to look after this work. Two counties have county engineers who serve under the orders of county commissioners.

Each town is governed by a board of from three to five selectmen elected by a majority vote of the voters at the annual town meetings. Cities and towns acting through their proper authorities, superintendents of streets, or highway surveyors, have authority to construct and maintain town roads and city streets and to raise and appropriate money therefor.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Massachusetts, comprising 18,681 miles, exclusive of city streets, are, for the purpose of fixing responsibility for construction, control, and maintenance divided into two main groups, namely, State highways and town ways. In addition to this, there are 4,349 miles of city streets, of which 3,812 miles have been surfaced. Town ways which receive the aid of the State and which are constructed and maintained under State supervision may be classified as follows: Small town act roads, through routes (chapter 525), five western county roads, and special act roads.

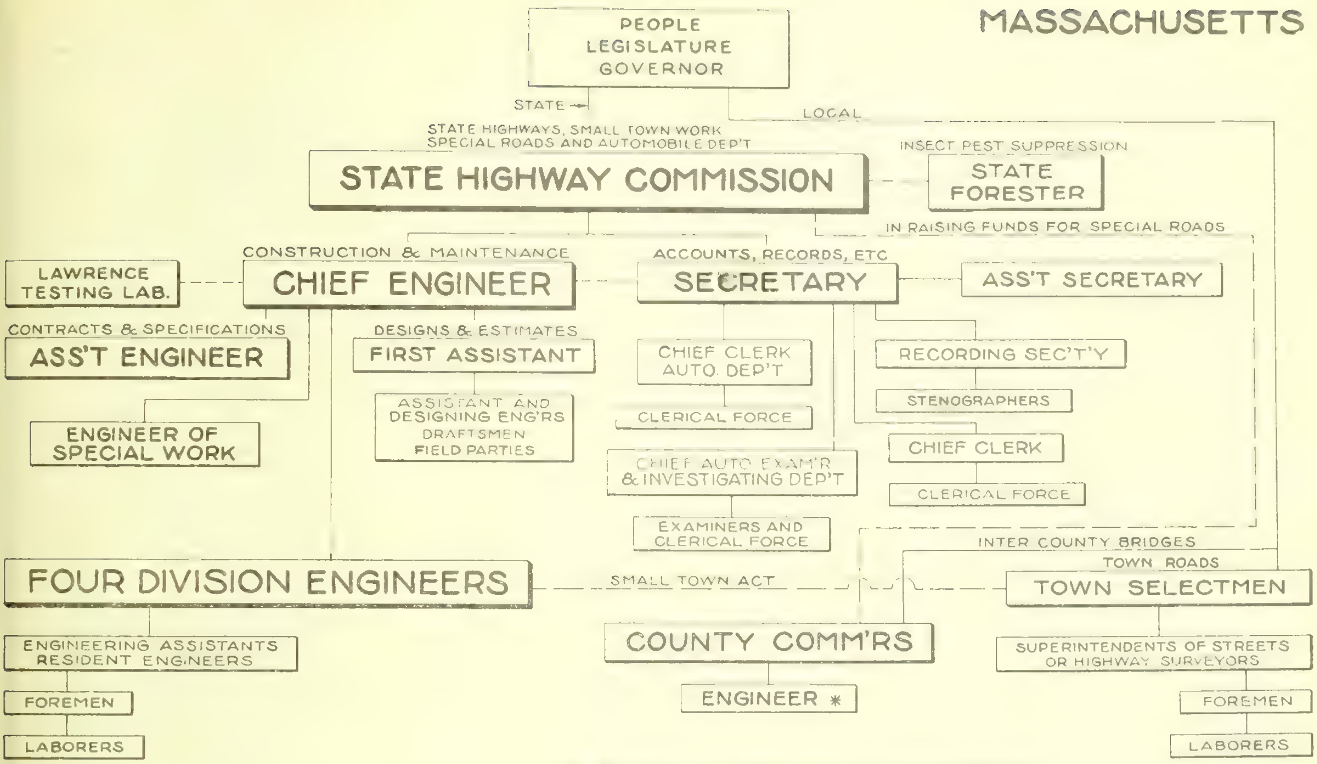
State highways.—The State highway commission has absolute control over construction and maintenance of State highways, which include at present about 1,200 miles. Petitions for construction originate with the county commissioners, town selectmen, or city officials. Surveys, plans, estimates, and description of layout are prepared and approved by the State highway commission and copies are filed with the county commissioners and with the clerk of the town or city in which the road is located. The road then becomes a State highway. Contracts may be awarded without advertisement to cities or towns for the work lying within their respective boundaries at a price agreed upon. If the city or town within 10 days does not elect to take the contract, the State may advertise and award the contract. Not more than 10 miles of State highway can be constructed in any one county in any one year without the approval of the governor and council.

Payments are made on monthly estimates, 15 per cent being deducted until final completion and acceptance. The State pays, from the State highway loan fund, 100 per cent of the cost of construction, but counties must repay within six years 25 per cent of the cost with interest at 3 per cent. On completion and acceptance the State maintains the roads, but the towns and cities in which such roads are located repay to the State from $50 to $500 per mile per annum on a valuation basis as follows:

In towns having less than $1,000,000 the basis of repayment is one-half the cost but not more than $50 per mile per annum; between $1,000,000 and $2,000,000 it is one-half the cost but not over $100 per mile; and between $2,000,000 and $5,000,000 it is one-half the cost but not over $200 per mile; and in cities and towns having a valuation of over $5,000,000, one-half of the cost but not to exceed $500 per mile in any one year. By this arrangement the State extends a greater amount of help to the poorer towns than to the richer ones. The amounts contributed by the towns and cities for this purpose may be levied and collected as a part of the State tax for the current or the three succeeding fiscal years, and when paid is added to the State highway fund. The State may upon presentation of sufficient reasons relieve the town from payment of any part of such repayment.

Small Town Act Roads.—The State highway commission may spend, subject to statutory restrictions, on town roads designated by town selectmen, 15 per cent of the amount appropriated for State highway construction, under the so-called small town act as follows: 5 per cent in towns having a valuation of less than $1,000,000, the towns making no contribution; 5 per cent in towns having a valuation of less than $1,000,000, the towns contributing an equal amount; and 5 per cent in towns having more than $1,000,000 provided the towns contribute an equal amount in addition to the average annual appropriation made by the towns for repairs for the preceding five-year period.

These roads are constructed under the direction of the State highway commission and the procedure for construction is practically the same as for State highways. The roads when completed remain town ways, and the town or city in which they are located assumes responsibility for maintenance. If after due notice by the commission repairs are not made within 60 days the State may do the work



* ONLY TWO COUNTIES HAVE COUNTY ENGINEERS

and collect from the city or town in which the road is located from $50 to $200 per mile, depending upon valuation. The State may upon presentation of sufficient reasons exempt any town from the whole or any part of such repayment. There are 580 miles of road which have been improved under the so-called small town act.

Five Western County Roads.—The legislature of 1915 authorized the State highway commission to construct between 1915 and 1918, inclusive, 17 specially designated roads situated in 38 towns and one city in the five western counties of the State. The procedure for layout and construction of these roads is practically the same as for State highways. The construction costs are paid from a $2,000,000 State bond issue, and the counties return to the State 25 per cent of the cost within six years in the same manner as for State highways. The roads when completed do not, unless laid out as such, become a part of the State highway system, the towns being responsible to the highway commission for their proper maintenance. This system of roads includes approximately 160 miles.

Special Act Roads.—There are about 30 miles of town roads in the State which have been designated by the legislature and improved by the State from joint State and town funds. These roads remain under town jurisdiction for the purpose of maintenance.

Through Routes (Chap. 525).—The State highway commission is authorized to set apart 20 per cent of the net receipts from the automobile fees fund each year for constructing, improving, repairing, and maintaining town roads which may be used as through routes. These roads are designated by the local officials with the approval of the State highway commission. Petitions for improvement originate with town selectmen. Construction work is under State jurisdiction and maintenance work is handled by the State or the town under State supervision. The commission may spend any part of the above 20 per cent fund together with any money contributed by the towns on these through roads, and the roads remain town roads. About 300 miles of road are included in this system of through routes.

Town Ways.—All town roads except those indicated above are under the jurisdiction of town authorities both for construction and maintenance. The county commissioners do not build or repair roads except on petition, and only then if the town authorities fail when ordered by them to do so.

REVENUES.

State revenues.—Appropriations are made by the legislature usually for five-year periods for construction of State highways and for aid to towns under what is known as the small-town act, 85 per cent of the appropriation being used at the discretion of the State highway commission for State highway construction and 15 per cent for small-town work. The last appropriation was made in 1912 and provided $1,000,000 per annum for each of the years 1913 to 1917, inclusive. This money is derived from State bond issues, specially authorized for the purpose. Appropriations are made annually by the legislature for the administration of the

State highway department, for maintenance of State highways, for widening and reconstruction of State highways, and other purposes.

An appropriation of $2,000,000 was made in 1915 for improving 17 designated routes in the five western counties of the State during the years 1915–1918, inclusive, the funds being derived from a State bond issue. The automobile fees funds which were collected by the State highway commission are used for the maintenance of State highways and for the betterment of through routes; 80 per cent of the net receipts being used for the former and 20 per cent for the latter purpose. The State funds available for the fiscal year December 1, 1916, to November 30, 1917, were approximately as follows:

State highway construction	$850,000
Aid to small towns	150,000
Administration of State highway department, including $20,000 for care of machinery and $10,000 for insect extermination, and $27,500 for maintenance and operation of 2 bridges	117,000
Maintenance of State highways, including $194,547 from assessments of cities and towns for maintenance of State highways	254,547
Widening and reconstruction of State highways	150,000
Maintenance of State highways (80 per cent of auto money)	1,440,000
Betterment of through routes (20 per cent of auto money)	360,000
5 western county roads (17 routes)	500,000
Total of all State funds available	3,821,547

Local revenues.—Funds for the construction and maintenance of local roads are chiefly derived from appropriations by town meetings or governing bodies of cities and from local bond issues. Funds used to repay the State for one-fourth the cost of constructing State highways and the 17 designated routes in the five western counties are secured from towns and cities in which the roads are located as a part of the proceeds of the State tax. At the present time the total revenues annually applied to roads and bridges constructed by the towns, exclusive of cities, amount to approximately $3,350,000.

BONDS.

State.—Since 1894 State bonds have been issued from time to time to meet appropriations for the construction of State highways. State bonds issued between 1894 and 1904 were of the sinking-fund variety maturing 26 to 30 years from the date of issue. All State bonds issued since 1904, except the last two issues, were deferred serials with the first payment falling due from 3 to 11 years from the date of issue, and the last payments from 9 to 30 years from the date of issue. In 1912, a bond issue of $5,000,000 was authorized to meet appropriations for each of the years 1913–1917, inclusive. These bonds are of the serial type and the last payment must be made in 15 years from the date of issue. Another issue of $2,000,000 was made in 1915 for the improvement of 17 routes in the five western counties of the State during the years 1915–1918, inclusive. These are also 15-year serial bonds. Up to the present time the State has issued approximately $16,250,000 of bonds, of which $14,250,000 were for State highways and $2,000,000 for 17 routes in the five western counties.

Local.—Towns and cities may issue bonds for roads, bridges, and other purposes by a two-thirds majority of votes cast at annual town meetings, or by two-thirds vote of all members of city councils or other governing bodies. Bonds may be issued up to 2½ per cent of the valuation in cities and 3 per cent in towns, and must be paid off in equal annual installments, the terms being limited as follows: For construction of stone, concrete, or iron bridges, 20 years; for construction of streets or highways of stone, block, brick, or other permanent pavement of similar lasting character, 10 years; and for macadam pavement or other road material under specifications approved by the Massachusetts Highway Commission, 5 years. The total town bonds outstanding for roads and bridges, exclusive of cities, amounted to approximately $1,600,000 on January 1, 1915.

MICHIGAN.

Development.—State participation in road improvement in Michigan is state-wide in its scope, has been effective since 1905, consists of allotments of State funds to the various counties of the State for construction purposes, rewards paid to counties or townships improving roads in accordance with statutory standards, of technical advice relating to and supervision of the construction of work financed with local funds, and is extended through the State highway department.

A system of State highways comprising 6 per cent of the total road mileage of the State has been designated for improvement by or under State supervision as rapidly as funds are available.

The "reward system" in effect in this State has induced local officials to improve their roads under State laws and general regulations provided by the State highway department, and as a result of this cooperation about 12 per cent of the entire road mileage of the State is now improved, most of the work having been done under this system.

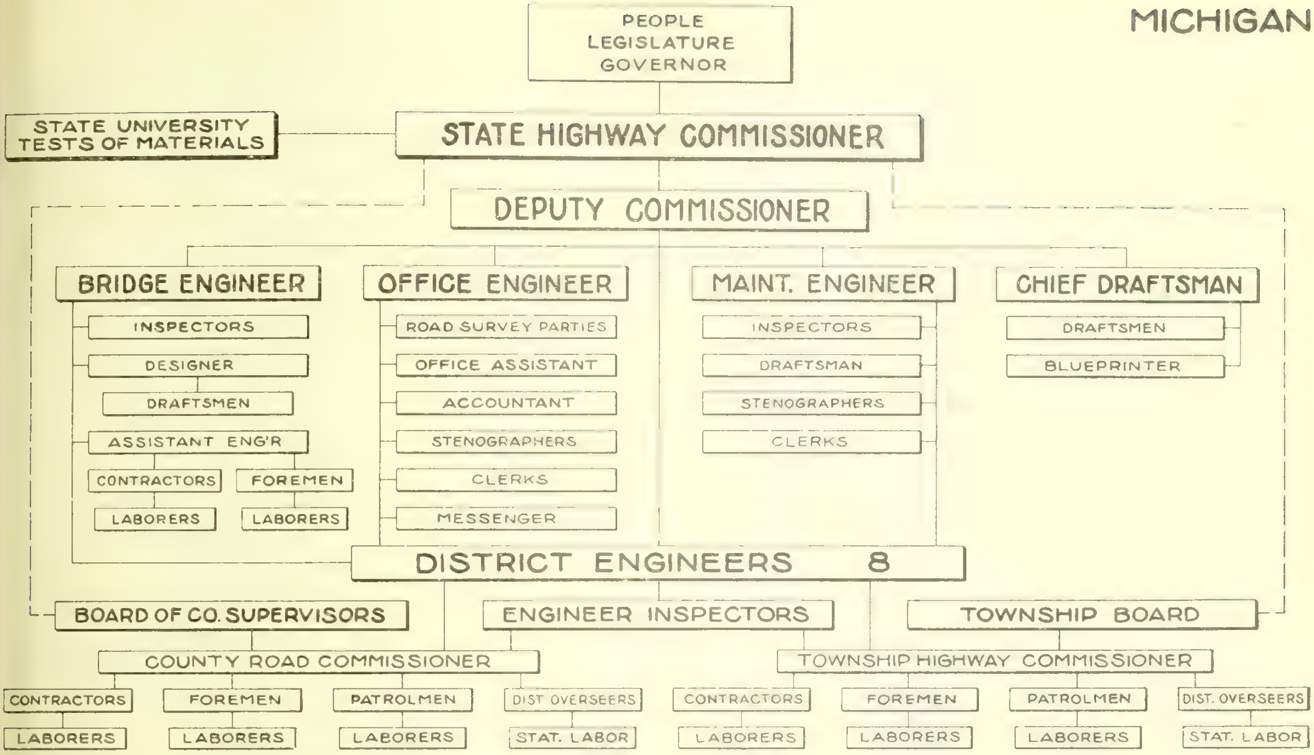
During 1916, $9,082,939 was expended in the State for road and bridge purposes. Of this amount $3,332,939, or 36.7 per cent was expended by or under the supervision of the State highway department, the remainder, $6,750,000 being expended by local officials. The total expenditure from all sources during 1917 amounted to $11,190,153.

ORGANIZATION.

The organization of the road forces of the State and the relation between them is shown on the diagram.

State.—The State highway commissioner, elected by the qualified voters of the State for a term of four years, is the head of the State highway department. Such assistants and clerical force as may be required are appointed by him. He has charge of all phases of the construction of roads and bridges financed wholly or in part with State or Federal funds. He furnishes plans and specifications for and makes inspection of the construction and maintenance of the "reward" roads. He is required to present to the attention of and discuss at the annual meeting of the township commissioners of each county such matters of road improvement as may be deemed of special interest to them. He is also required to prepare a map of each township of the State showing all public roads, their condition, and the location of available road-building material. He is required to act as a technical adviser to all

MICHIGAN



road officials of the State and present a biennial report to the governor covering all operations of the State highway department. He is assisted in the discharge of his duties at the central office by a deputy commissioner, who is required to be a civil engineer, by a bridge engineer, an office engineer, a maintenance engineer, draftsman, and other employees, and in the field by eight district engineers, who have charge of supervision and inspection of State construction and State reward work.

County.—Fifty-eight counties have adopted the county-road system and control of the roads therein is vested in a board of three commissioners, generally elective. The county clerk is clerk of the board and the county treasurer is fiscal agent.

In counties containing 20 or more entire or fractional surveyed congressional townships the board of commissioners may be appointed by the county board of supervisors.

The board of commissioners of each county so organized is required on or before October 1 of each year to prepare a budget covering the estimated road expense and the tax levies for the coming year, and to present same to the county board of supervisors, who may make amendments therein, although they are required to provide sufficient funds for the proper maintenance of the roads in their jurisdiction.

Township.—Twenty-five counties exercise road control by means of township boards consisting of the township supervisor, the township clerk, and the two senior justices of the peace. This board appoints a township highway commissioner and an overseer of highways for each road district in the township.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 94,100 miles of public road in Michigan are, for the purpose of fixing responsibility for construction, control, and maintenance, divided into three groups, viz, trunk-line highways, county roads, and town roads. As State reward may be granted under certain circumstances to roads of the various groups, a brief discussion of the State reward systems will be outlined at this time. State refunds are granted under the reward system authorized by the legislature and are applied to roads constructed in accordance with seven standard types. Class A roads are 20 feet wide between ditches, with a 9-foot traveled track of clean gravel or sand-clay, being the cheaper type of construction, while class G roads are 20 feet wide between ditches, with a brick-paved surface 9 feet wide laid on gravel, sand, broken stone, or slag, represent the highest type of construction. The rewards vary from $250 per mile for class A roads to $1,000 per mile for class G roads. These amounts are increased by 10 per cent for each additional foot in width of wearing surface up to and including 16 feet. These rewards are doubled on trunk-line or State roads if full control over construction is vested in the State highway department. The roads to be improved under the reward method are designated by joint agreement between the State highway department and county or township board. The State highway department furnishes the necessary plans and specifications and inspects the work when completed. The reward is paid to the county or township fiscal agent when the completed work has been accepted by the State highway department. Maintenance is executed by and at the expense of the local unit. State rewards may be withheld to compel proper maintenance.

The State builds and pays the cost of construction of all bridges greater than 30-foot spans on State rewards roads provided the local unit expended on road or roads including bridge sites, an amount not including State reward, equal to the cost of the bridge plus the State reward mentioned on the road or roads built.

In addition to the reward system, the laws of Michigan grant State or Federal aid for construction purposes when control over location and construction is vested in the State highway department.

When such aid is invoked the procedure is substantially as follows:

The county or township designates the road to be improved, pledges funds therefor, and requests Federal or State aid. The State highway department views the road, approves the project, prepares surveys, plans, specifications, and notifies the local board of the estimated cost and the amount it must deposit with the State treasurer to the credit of the State highway fund. The percentage of cost paid by the township or county board is fixed by statute and is computed as follows: The total assessed valuation of the county or township is divded by the number of miles of trunk line road allotted to the county or township. When the quotient is $100,000 or less, the local board pays 25 per cent of the total cost; as the valuation of the county increases, the percentage of cost borne by the local board is increased up to 50 per cent of the total cost, the State contributing the remainder. The cost of surveys and plans is paid from State funds.

Trunk-line highways; or State roads comprising about 4,500 miles are designated in a general way by the State legislature, the details of location being left to the State highway department. They are constructed and maintained by the State highway department with Federal, State and local funds. Local funds are contributed annually for maintenance purposes in an amount equal to 3 per cent of the local contribution to the cost of construction, provided, however, that this contribution may not exceed $100 per mile. The mileage of trunk-line highways in any county may not exceed 3 miles for each surveyed township.

Trunk-line highways may be constructed with local funds by local officials, the plans, specifications, and supervision being furnished by the State highway department. On satisfactory completion of the work, double rewards are paid to the local board. The maintenance of such roads may be carried out by the local boards subject to state supervision.

County roads. These are designated, controlled, improved, and maintained by the county boards with local funds. Single rewards are paid for improved roads if constructed in accordance with State law, and the rules and regulations of the State highway department.

Township roads.—These comprise all other roads of the State not included in the preceding systems. They are constructed and maintained by township officials with township funds. Rewards may be paid for improved roads of this group, although it is the desire of the State highway department to give preference in construction to roads of the preceding groups.

Convict or reformatory labor may be utilized on trunk-line and county roads when requested by local officials, all expense being borne by the local board and an additional charge of 50 cents per day for each person employed. County prisoners may also be detailed to road work by the county board of supervisors.

Improvement of roads of the three groups may be executed under contract or force account. The State highway department may let contracts for work done by districts authorized to levy special assessments and located in two or more counties; for all bridges of 30-foot span or more located on State trunk-lines; for all work done by contract in counties having no county organization; and for all projects involving the expenditure of Federal and State aid funds. All other contracts are let by the board having jurisdiction over the roads.

Partial payments may be made at monthly intervals when based on estimates prepared and approved by the engineer in charge of the work. The approved estimate is then submitted to the executive official or board in charge of the funds provided for the work and payment may be made on his or their order. Final payment may not be made until the contractor has filed an affidavit showing that all accounts incurred by him on account of the work have been paid, and until the completed work has been inspected and approved by the proper authorities.

REVENUES.

For the year ended June 30, 1918, the State legislature provided the following amounts for the use of the State highway department.

For support of the State highway department	$30,000
For State aid on construction of Federal aid roads	225,000
For bridges and State reward on trunk line routes......	550,000

In addition to these amounts the State highway department has at its disposal 50 per cent of the net automobile revenues which will produce it is estimated $1,272,246, which may be used for the payment of single State reward and maintenance rewards.

County and township funds. These are raised by taxation or by bond issues. When by taxation, two levies are made consisting of (1) the road-repair tax laid on all property outside the limits of incorporated villages or cities, and may not exceed 50 cents on each $100 of valuation, except in townships having a valuation less than $200,000 where the tax may not exceed $1 on each $100 valuation; (2) the highway improvement tax laid on all property in the township at the same rates as given for the road repair tax.

Bonds.—Bonds may when authorized by a majority of the voters affected be issued for road purposes in an amount not to exceed 5 per cent of the assessed valuation of the township or three per cent of the assessed valuation of the county.

It is estimated that on January 1, 1915, $10,389,929.43 of county and township bonds were outstanding. These bonds bore interest at rates of 4 per cent and 5 per cent and had terms of 15 to 20 years.

NEW ARIZONA STATE ENGINEER.

State Engineer B. M. Atwood, of Arizona, resigned January 6, to go into the contracting business, with road work a specialty. F. N. Holmquist of Phoenix has been appointed to succeed him. Mr. Holmquist is a graduate of the University of Chicago, class of 1909. He has lived in Arizona most of the time since his graduation, has served as city engineer of Phoenix, and when appointed was in private practice in that city.

ALABAMA ROAD LEGISLATION.

The Alabama Good Roads Association is pushing road legislation wanted from the legislature now in session. It is advocating increased appropriations for highway building, the use of the automobile license tax in maintaining roads and a law to work convicts on the highways.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913). 15c.

DEPARTMENT BULLETINS.

Dept. Bul. *53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912-13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
220. Descriptive Catalogue of Road Models of Office of Public Roads.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges, from July 1, 1913, to December 31, 1914. 10c.
314. Methods for the Examination of Bituminous Road Materials.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
370. The Results of physical Tests of Road-Building Rock.
373 Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463 Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
555. Standard Forms for Specifications, Tests, Reports and Methods of Sampling for Road Materials
583. Report on Experimental Convict Road Camp, Fulton County, Ga
586. Progress Reports of Experiments in Dust Prevention and Road Preservation. 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETIN.

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

YEARBOOK SEPARATES.

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10. No. 5. D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10. No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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*Department supply exhausted

*Department supply exhausted.

Stricken Europe Needs Our Help In Period of Recovery, Says Secretary

NOW, the great struggle has been won by the forces of civilization, and this Nation is free—at least temporarily free—to take up once more the tasks of peace. It has issued from the contest, comparatively speaking, untouched and unhampered. By reason of its shorter actual participation in the war and its freedom from such devastation as has swept Europe, its relative position industrially, financially, socially, and governmentally is stronger than it was five years ago. The world does not yet realize how stricken are the European countries and how long it will take them to recover and to make their former material contribution to the world's stock.

It is impossible yet for one to frame in his mind a complete picture of the disabilities under which all Europe labors. It has been estimated that the European belligerents, exclusive of the Balkan States and Turkey, lost more than seven millions of men killed and fourteen millions wounded, many of them permanently incapacitated, a total casualty list of over twenty millions. The impairment resulting from these losses and the burden imposed by great numbers of widows and orphans can not be calculated. And what of the destruction of property, the enormous losses of merchant ships, the disruption of industry?

We must think, too, of the immense upheaval in the social, economic, and political field, of the years of struggle that will ensue before Governments are reorganized and orderly political processes are restored. In Central Europe the old régime will not reappear. For the first time in their lives the masses of the people will have an opportunity to say something about their future and to take part in the direction of the Government. They will not be content with the restoration of former conditions and will demand things in the way of political participation, of standards of living, and of wages that will constitute a revolution.

Obviously, also, account must be taken of the enormous debts, the principal of which must be ultimately discharged and the interest paid. It is probable that the war debt of all the belligerents will range from $175,000,000,000 to $200,000,000,000. It is estimated that that of Great Britain will exceed 32 billions, 37 per cent of her estimated real wealth, and $700 per capita; that of France, more than 25 billions, 50 per cent of her wealth, and $600 per capita; that of Germany, 33 billions, 40 per cent of her wealth, and $560 per capita; that of Austria, 18 billions, 76 per cent of her wealth, and $316 per capita; that of Italy, 7 billions, 30 per cent of her wealth, and $200 per capita; while that of the United States may be 20 billions, only 11 per cent of her wealth, and $200 per capita.

And yet there are those who express alarm as to the future ability of this country to hold its due place in the trade of the world. There are doubtless others who may take smug satisfaction in the thought that Europe will be relatively handicapped. Many among us still entertain medieval notions of trade, and foolishly think that one nation can gain only at the expense of another or that it is possible for a nation to secure what it needs from others without giving an adequate return. It is incredible that any thinking man can gain satisfaction from an impairment of the capacity of any part of the world to contribute to the world's national dividend of goods and services.

Our thought, it seems to me, should be how, in the period of recovery, we may properly assist the desperately stricken people of Europe rather than of how we can take advantage of them in their present plight.—*From address by Secretary Houston.*

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. I, NO. 10 WASHINGTON, D. C. FEBRUARY, 1919

BRICK SECTION, EXPERIMENTAL ROAD, CHEVY CHASE, MARYLAND

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1919

Recent issues of Public Roads have contained chapters on "State Highway Management, Control and Procedure." It was the original intention to give in each issue the chapters devoted to eight or ten States, but it has not been possible to do this. The articles have, however, been of such interest and the demand for the additional chapters is such, in connection with pending road legislation in many States, that in order to make them available at once, most of the space in this issue is devoted to the completion of the series.

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both Houses of Congress. Others desiring to obtain "Public Roads" can do so by sending 15 cents for each number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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State Highway Management, Control and Procedure 29
By M. O. Eldridge, G. G. Clark, and A. L. Luedke.

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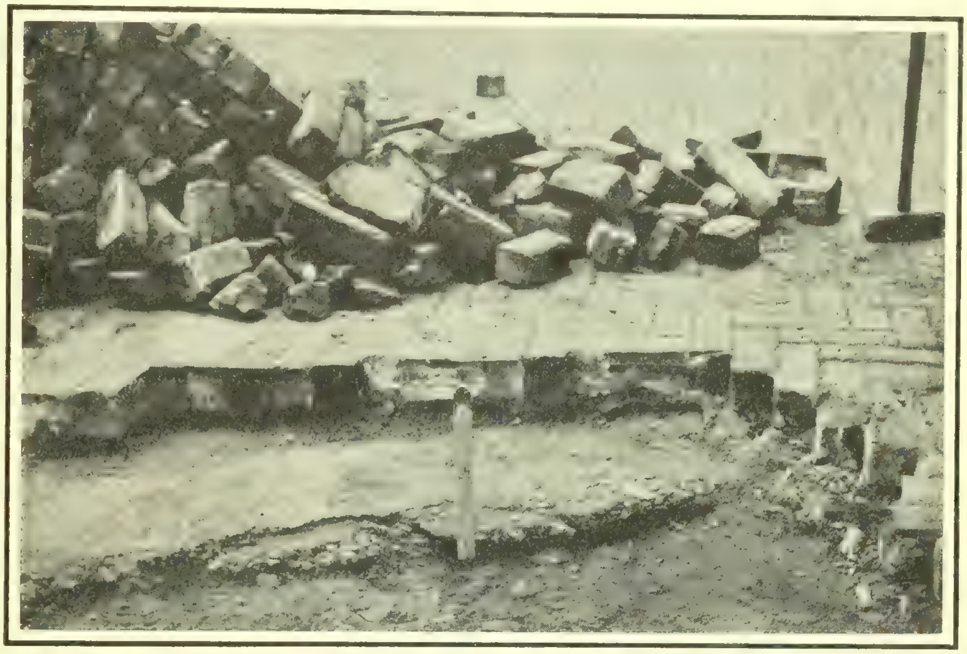
BRICK PAVEMENTS IN THE MIDDLE WEST.

Report of Inspection by A. T. GOLDBECK, Engineer of Tests, and F. H. JACKSON, Assistant Testing Engineer.



CONCRETE BASE, CONNEAUT, OHIO, SHOWING RESULT OF SLOPING JOINT. EXPANSION HAS CAUSED ONE SECTION OF BASE TO SLIDE UP AND OVER THE OTHER.

THE following report is based on a recent inspection by the authors of a large number of brick roads throughout the Middle Western States. Although particular attention was given to a study of the merits of "semimonolithic" and "monolithic" brick roads, other points affecting the design and construction of brick highways were studied as well. The behavior under traffic of various types and sizes of brick, as well as different joint fillers, was noted and compared, and numerous modifications in design and interesting details of construction, etc., were observed. Furthermore, every failure encountered was analyzed for the purpose of determining its cause as well as suggesting means for guarding against similar failures in future work. In this way it was hoped that first-hand information might be obtained regarding the various problems encountered in the construction of brick roads, as well as the possibilities in the way of modification in design to meet different conditions.

The tour of inspection extended over city streets and county highways in six States—Ohio, Indiana, Illinois, Iowa, Missouri, and Nebraska and covered a period of 16 days. One of the outstanding results was the remarkable state of preservation of roads that had been under traffic for from 20 to 25 years.

A detailed report of the various streets and roads examined follows:

CLEVELAND'S OLD STREETS GOOD.

Most of the pavements in the city proper are laid on a natural-soil foundation, which, in the main, consists of a fine sandy loam. Most of these old streets are in good condition, and such longitudinal cracks as have formed are probably the result of poor drainage. Where good drainage conditions were found, very few longitudinal cracks were in evidence. Various failures of grouted brick streets laid on sand cushions were noted. These included the charactersitic arching of the grouted brick surface over the sand cushion, due to expansion as well as the falling away of the sand cushion due to the vibration of traffic. This condition was particularly noted at street intersections and was determined by listening to the peculiar rumbling sound made by iron-tired vehicles when driven over the street. Spalling at the joints of the brick was likewise frequently observed. This condition was brought about by imperfect penetration of the grout into the joints, which had become partially filled with sand forced up into them from the underlying sand cushion during the rolling of the brick, or to too thin a joint due to imperfect lugs.

It was stated that about 75 per cent of the brick streets of Cleveland are laid on natural soil-foundation. Practically all of the older streets are constructed with standard re-pressed block, with cement grout filler. The present standard construction in the city, however, provides for a monolithic or semimonolithic street with a 4 to 6 inch concrete base, sand-cement bed, and wire-cut lug brick.

A number of the older brick streets of West Cleveland were examined for the purpose of noting their condition after 18 or 20 years' service on the natural soil foundation. These streets were laid about 1900, and with one exception are in very good condition to-day. Their general freedom from longitudinal cracks appears to be due principally to the fact that they were laid on a naturally well-drained subsoil.

The results of using a poor grade of brick were noted on West Fourteenth Street, which is a through street extending west from the center of the city. Brick in this case were laid on a 6-inch concrete base, with 2-inch sand cushion. Pockets varying in size from less than a square foot to 1 or 2 square yards were frequently observed. They were due probably to the use of inferior brick in the pavement or possibly to an excessive sand cushion. The rattler loss on these brick was stated at 30 per cent, old rattler test.

A number of streets in the eastern part of Cleveland, in general, showed characteristics as mentioned above. One very old sand-filled pavement made with building size brick was of particular interest in view of its splendid condition after about 25 years of service. The edges of the brick were somewhat worn and rounded, but otherwise there was no appreciable wear.

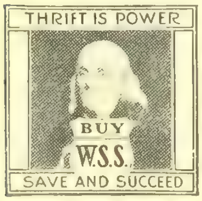
ON THE CLEVELAND-AKRON ROAD.

Inspection of the Cleveland-Akron road brought out some very interesting facts. This road has failed recently at a number of points due to the present extremely heavy traffic between the two cities. This traffic consists principally of very heavily loaded automobile trucks and local officials claim that the road carries a greater tonnage than any other intercity highway in the United States. The following table shows the construction record for the road:

Section.	Between limits.	Length (miles).	Built—	Construction.
1	Cleveland-Tinker Creek	6.2	1906	Brick.
2	Tinkers Creek, Top of Hill	.2	1916	Do.
3	Top of Hill, Summit County line	2.8	1916	Asphalt-concrete.
4	County line, Twinsburg Township	2.4	1915	Brick.
5	Twinsburg Township, Twinsburg	1.2	1912	Do.
6	Twinsburg-Stow Township line	4.1	1913	Do.
7	Stow-Hudson line, Cuyahoga Falls	7.0	1912	Do.
8	Cuyahoga Falls, Cuyahoga Falls Avenue.	.4	1916	Do.
9	Cuyahoga Falls Avenue, Akron	1.0	1912	Do.

Section 1, laid on rolled slag base with 2-inch sand cushion.
Section 2, laid on 6-inch concrete base, 1-inch cement-sand cushion.
Section 3, 2-inch top on 7-inch concrete base.
Section 4, laid on 4-inch concrete base on 2-inch crushed slag cushion.
Section 5, laid on concrete base on 2-inch sand cushion.

The failures on this road had either been repaired or were being repaired at the time of inspection. They occurred for the most part in the early spring of 1918, and in nearly every instance could be traced directly to poor drainage conditions. More failures occurred on section 1, which was laid on a rolled slag base, than on any of the other sections of the road. The conditions observed were probably due to the overloading of the base by traffic at a time when the earth foundation was saturated with water, thus greatly decreasing its bearing value. An inspection of various places on the road where failures had taken place confirmed this theory.



THRIFT IS POWER ••• SAVE AND SUCCEED
BUY
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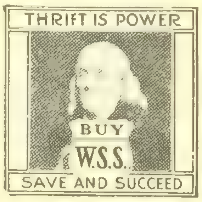


THE CUYAHOGA COUNTY ROADS.

Most of the roads inspected in Cuyahoga County had been down for some years and were of the standard sand cushion type. The outstanding features noted were the large number of longitudinal cracks, and also the typical failures due to the pushing up during construction, of the sand cushion between the brick joints, which resulted in imperfect grouting. Failures of sand cushion pavements in this way are to be noted in a great many instances and are characterized by the cracking of the brick in small areas, sometimes accompanied by the flaking off of the top surface.

None of the roads in Cuyahoga County is subjected to the extremely heavy traffic carried by the Cleveland-Akron road. Typical foundation failures of the extreme type noted in the Cleveland-Akron road therefore were not in evidence, although there are places where failure of the pavement could be attributed to insufficient bearing value of the subgrade. By referring to a soil map of Cuyahoga County, it will be noted that the predominating soil is a clay loam and this, in all probability, is highly retentive of moisture The high percentage of longitudinal cracks observed may be attributed to this characteristic of the soil, which permits great expansive action due to the severe frost in this section.

Two recently laid monolithic brick roads were in very good shape, but were somewhat rougher than the standard sand cushion type.

AT CONNEAUT, OHIO.

Of the brick streets in Conneaut, Ohio, Main Street was of peculiar interest on account of the fact that it was laid about 25 years ago, and had been continuously subjected to a considerable amount of traffic such as might be expected on the main street of a town with a population of 12,000. This street is also on the main highway between Cleveland and Buffalo and the East.

When visited, the street department was about to repair a heave which had occurred some years before, and it was decided to inspect the work of removal of the brick, in an effort to determine the cause of the failure. Upon removal of the brick it was noted that the sand cushion had not separated from the brick that had heaved, but had readjusted itself under them, showing that the failure was not primarily due to expansion of the brick pavement. Upon removing the sand cushion it was found that the heave had taken place over a sloping joint in the concrete base and that it was due to the sliding up of one section over the other when expansion of the base took place, thus causing the brick surface to rise. Fortunately, one of the workmen who constructed this street was detailed to make the repairs and had a distinct recollection that the day's work was ended at this particular spot. He also stated that broken stone had been used in the concrete on one side of the joint and that gravel had been used in continuing work.

This type of failure emphasizes the necessity for constructing joints in the concrete base by putting up a vertical bulkhead, such as is used in good present-day practice. The accompanying illustration shows the concrete base after removal of the sand cushion, and the angle of slope at the end of the day's work is seen very plainly. The amount of rise of one section over the other was about 2 inches. The same kind of a failure was noted one block away on the same street.

An interesting instance showing the relative amount and kind of wear to be expected from a grout-filled and a bituminous-filled pavement was noted on a business street in Conneaut where transverse joints consisting of six or seven courses of bituminous-filled brick were used. The edges of the brick at the expansion joint were battered down and some of the brick were badly worn, whereas the brick having a Portland cement grout filler were quite smooth along the edges and did not seem to be breaking out. This sort of failure is quite characteristic of the brick in many bituminous-filled pavements.

An interesting case of frost action was noted in a newly laid semimonolithic brick pavement. All construction details had received careful attention, yet during the winter the pavement heaved at the center, causing a wide longitudinal crack to form. Levels run by the city engineer showed the amount of this heave in the center to be about 3 inches, with very little vertical movement at the sides. The explanation was made that this difference in vertical movement was due to the protective action of the uncompacted snow at the sides of the road, which prevented the penetration of the frost to as great a depth as at the center. The city engineer likewise determined the frost penetration and found that at the center of the pavement the ground was frozen to a much greater depth than at the sides, thus bearing out this theory.

It is to be noted that the subgrade on this street consisted of a sticky clay. In other parts of the city, on the other hand, pavements which had been laid on the sandy soil existing there remain practically free from cracks of any kind. This is almost certainly due to the better drainage afforded by the more porous foundation, and is another instance of the effect of the character of the subgrade on the pavement. When the subgrade is of a porous nature and is well drained, heaving is much less likely to happen than where the subgrade is composed largely of clay which is highly retentive of moisture and hard to drain. Likewise, when the frost comes out of the ground, the porous, easily drained soil is able to support the pavement under much heavier live loads than is the poorly drained moisture retaining soil, consequently decreasing the chances of a foundation failure.

FAILURE OF CONCRETE GUTTER ON CURVE, NEAR CONNEAUT, OHIO. NOTE THE SMALL BATS AT THE ENDS OF THE COURSES OF BRICK WHICH ARE STILL INTACT.

A type of failure somewhat common in city pavement work is shown herewith. This view was taken near Conneaut of a pavement laid on a rather steep grade on a curve, and with 1-inch sand cushion. The concrete gutter has been worn by traffic into a groove about 4 inches wide and from 2 to 3 inches deep. This was aided perhaps by the original width of the bituminous-filled expansion joint between the gutter and the pavement. This joint was probably three-fourth inch in width. It can be seen in the illustration that although traffic has been grinding along the edges of the brick pavement, none of the brick has been displaced, not even the small bats serving as fillers at the end of the courses.

This is an extreme case of traffic grinding along the edge of a brick pavement. The bats at the end of the courses are likewise very small, so that the conditions are very favorable for the breaking down of the edges of the pavement by displacement of the brick. The fact that such displacement has not occurred is a good indication that the protecting action of a concrete curb along the sides of a monolithic or semimonolithic brick road is unnecessary. This observation was borne out in the inspection of a number of monolithic pavements constructed without a concrete curb or edging.

USING VERTICAL FIBER BRICK.

Near Conneaut, Ohio, a monolithic brick pavement was in course of construction and was of peculiar interest in that vertical fiber brick were being used. A detail of the brick laid on the wet concrete foundation and before the grout had been applied is shown. It will be noted that the lugs at the sides of this particular type of vertical fiber brick occupy a considerable area of the sides of the brick, and thus reduce the area of the surfaces to be grouted together, because the grout can not penetrate where the lugs are in contact with adjacent brick. On monolithic and semimonolithic work it is of the highest importance that the side bond be as strong as possible, so as to protect the bond between the brick and the concrete base. This can best be secured by having as large a proportion as possible of the area between the brick filled with grout.

ROADS IN THE VICINITY OF GOSHEN, IND.

A very good example of the semimonolithic type was observed in the new Paris road near Goshen, Ind. It was built with a 3½-inch concrete base, a 1-inch cement-sand bed, and 4-inch wire-cut lug brick. The road is 16 feet wide and carries considerable through traffic. It was in very good condition and no longitudinal cracks were noted.

An interesting expansion failure was observed on the Lincoln Highway, west of Goshen, which at the point in question is 14 feet wide and built on a gravel base and 1½-inch sand cushion, with 6 by 12 inch concrete curbs at the sides. The failure occurred on a curve at the intersection of two long tangents. As a result of temperature stresses in the pavement during the present summer, the pavement was pushed out at the curve to a distance of 9 inches at the point of greatest movement, leaving the curb on the inner side and sliding up and over the outside curb. The detail view shows the inner curb. The remarkable fact about this failure was that as far as could be observed there was no breaking up or crushing of the pavement itself.

Another interesting failure was observed on Prairie Avenue, near Goshen. This is typical of a number which have taken place on this road. It has been down five years and is sand-cushion type of construction. The longitudinal cracks and settlement at the edges of the road probably are due either to the shifting of the sand cushion or to carelessness in construction, since the traffic is not heavy enough to have produced failure.

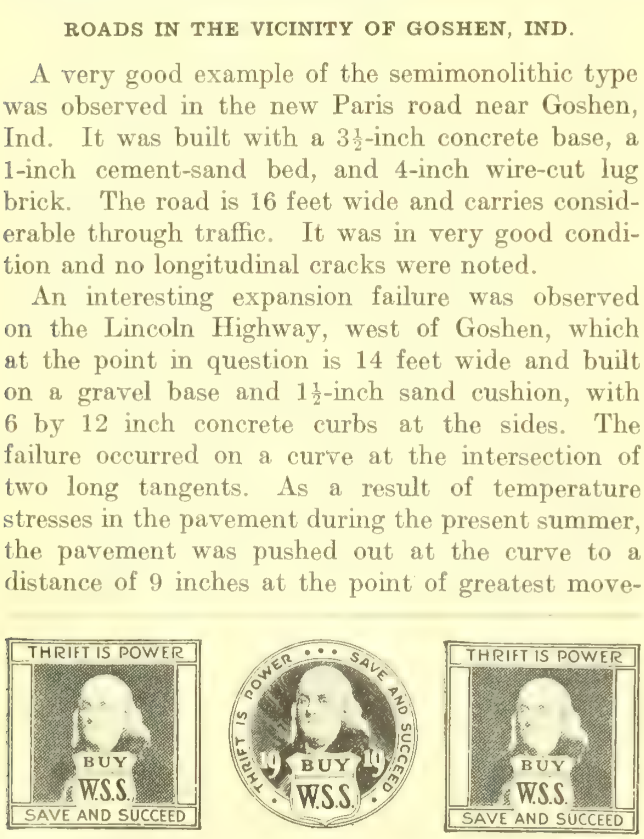
An interesting example of failure due to poor grouting was observed on the East Lincoln road, which is 16 feet wide and was laid on a gravel base with 1-inch sand bed and 6 by 12 inch curbs at the sides. The breaking up of the brick is due to poor grouting, which failed to properly protect the edges under traffic. This condition is typical where proper attention is not paid to grouting at the time of construction, and emphasizes the necessity of the utmost care being paid to this detail.

ROADS NEAR PARIS, ILL.

The Springfield road was built in 1915 and consists of a 4-inch brick surface on a 4-inch concrete base. It is 10 feet wide over one section and 13 feet wide over the rest of the road. The traffic consists of grain and coal hauling, automobiles and heavy trucks. Transverse cracks have occurred in this road from 25 to 75 feet apart. These, however, are barely noticeable and do not seem to have any deteriorating effects on the road. The surface is quite smooth, and there are no signs of disintegration. The road is an excellent example of the monolithic type of construction.

The Cherry Point road is built on a 4-inch concrete base with a 1½-inch sand cushion and is 6 years old. It is rougher than the monolithic type on the Springfield road. The surface, however, is in very good condition.

A monolithic road under construction at Paris was 10 feet wide with a 4-inch brick wearing surface and a 4-inch concrete base. A new tamping template was being used in constructing the concrete base. It is made of structural shapes in the form of a truck upon which is mounted a gasoline engine. The truck runs on the steel forms at the sides of the concrete base. The forward and rear I-beams serve to strike off the concrete. A steel frame is set inside of the main frame of the machine and is oscillated by the gasoline engine, so that the forward and rear beams of the oscillating frame tamp the concrete as the frame rocks. The rear I-beam



of the main frame serves to give the concrete a final smoothing off. The device is provided with drum and wire cable for propelling itself forward. The concrete after treatment with this machine is so well tamped that it will bear a person's weight with an indentation of perhaps only one-eighth inch

On this particular work the brick were set in the green concrete immediately after laying. Some detail photographs were taken to illustrate interesting points in connection with the laying of the brick. In one a number of the brick had been removed from the green concrete base. The concrete was found to be indented, and extended up into the joints between the brick. The ridge thus formed should be of material aid in resisting horizontal shear at the plane of junction between the brick and concrete. The green concrete adhered to a few of the brick. On the other hand, many of them were removed without the slightest difficulty and without any sign of the concrete sticking to them.

VERTICAL FIBRE BRICK READY FOR GROUT, NEAR CONNEAUT, OHIO. NOTE THE NARROW GROUT SPACES BETWEEN BRICK AT CERTAIN POINTS.

In this particular case of monolithic construction it is the opinion of the authors that the contractor was using too dry a mix. It would seem preferable for the concrete to be of such a consistency that the process of tamping will bring a thin coat of mortar to the top and that the brick should be set immediately in this green soft grout. In this way very good adhesion should be developed between the brick and the concrete due to (*a*) better adhesion at the horizontal surfaces and (*b*) a greater projection of the grout up into the vertical joints. If the grouting of the brick were then done immediately a truly monolithic construction probably would result.

There is also shown a method of laying brick on a curve, whereby the use of small bats is eliminated by laying the course of longitudinal brick and the transverse courses extending to this longitudinal course in the form of saw teeth. Treatment at the side of the pavement is shown. Here the small bats are set not at the edge of the pavement, where they would be in more danger of being displaced, but at the inner end of the whole brick placed along the edge. This detail probably aids in preventing the edge of the pavement from being battered by steel-tired vehicles.

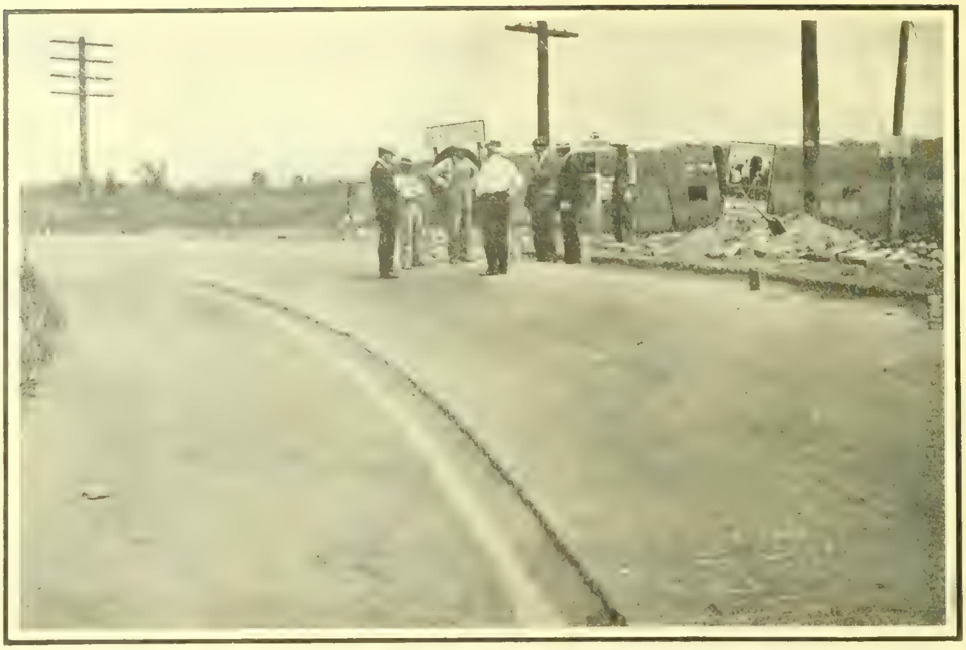
ROADS NEAR DANVILLE, ILL.

The Danville-Tilton road is of peculiar interest because of its radical type of construction. It is built on a concrete base with a sand-cement cushion and wire cut lug brick, laid on their sides with lugs down. Bituminous filler was used. The joints of this road do not seem to be well filled. The brick are chipping at the edges, and there are soft brick in spots. This road was built as an experiment about one year ago and its behavior is being watched with interest.

The base of the Danville-Batestown road was an old brick road made of building brick, sand-filled, and laid about 15 years ago. Under heavy traffic the old road had settled very badly, making an uneven pavement. This foundation was covered with a course of 1–2–3 concrete, using pea-size gravel. Just enough concrete was used to level off the base. Wire cut lug brick were set directly in the green concrete and then grouted. At one end of the road 3-inch brick were used and at the other end the brick were 4 inches thick.

The resurfacing work was done about one year ago, and the road was in good condition when inspected.

A short section of experimental road near Danville was built of wire cut lug brick laid on 1, 2, and 3 inches of concrete, respectively. It was built in 1915, and since then subjected to heavy traffic. All of the sections are in uniformly good shape. There is no difference in their appearance. It might be pointed out that the idea of using so thin a base as 1 inch of concrete was simply to prevent the soil from being pushed up into the vertical joints in the brick, as well as to provide a bedding course upon which to lay them. More perfect grouting of the brick is thus insured. The same results probably would have been secured by the use of a 1 inch sand-cement bed, such as noted on other roads.



HORIZONTAL EXPANSION ON CURVE, LINCOLN HIGHWAY, NEAR GOSHEN, IND. THE PAVEMENT IN THE FOREGROUND HAS MOVED OUT FROM THE CURB FOR A DISTANCE OF NINE INCHES.

The condition of this section brings out very forcibly the possibilities of light design for the monolithic construction when the conditions are favorable. In this, as in other cases of light construction sustaining heavy traffic, the underlying soil is of a character which permits good drainage so that it is possible to keep the foundation dry and thus maintain its bearing power. On the other hand, a soil such as the clay of Cuyahoga County, Ohio, which retains and attracts moisture through capillary action and is hard to drain, loses the greater part of the bearing power it would possess in a dry state. Light construction would obviously be poor engineering under such conditions.

It has, moreover, been observed that even a 4 to 6 inch concrete base, as on the Cleveland-Akron road, although undoubtedly helping to distribute the loads, sometimes fails to properly support the surface. This whole question of the character of the underlying soil and the part it should play in the design of a road surface is one that unquestionably deserves careful study.

An interesting feature in connection with this experimental road was the fact that a previous inspection made by the county engineer had shown that a monolithic bond existed between the base and the brick. He stated that he had occasion to take up a considerable area of this pavement after it had been under traffic for some time and that the brick adhered to the concrete very well.

At Hoopeston, Ill., was noted an interesting method of laying brick on a curve on the Lincoln Highway. The brick were laid longitudinally around the curve, instead of transversely as in general practice. Close inspection of this curve showed no fects, indicating that this method of construction is satisfactory. This road is 2 years old and is subjected to fairly heavy traffic.

ROADS NEAR DIXON, ILL.

A section of the Lincoln Highway near Dixon is of grouted repressed brick laid on a sand cushion and on old macadam base. Before the brick were laid the macadam base was widened, and there is considerable settlement at the side of the road, causing failure of the brick surface at these points. This fact emphasizes a point which has often been brought out, viz, that in order to prevent unequal settlement of the subgrade it must receive uniform compaction. When additional broken stone is placed alongside of an old macadam road it is a very difficult matter to roll the shoulders to the same degree of compaction as in the old macadam road. It is the opinion of the authors that it is advisable to plow up the old macadam base and reroll it over the entire width in order that it may be compacted evenly, and thereby settle evenly. There are some longitudinal cracks in the center of this brick road. In general, however, the surface is in very good shape except where settlement has taken place. These bad spots probably could be repaired satisfactorily by the application of bituminous material and stone screenings.

The Lincoln Highway west of Dixon is of semimonolithic construction with a ¾-inch sand-cement bed and a 4-inch concrete base. There is no edging of concrete at the sides of the road and no evidence of breaking down of the brick. The road is only one year old but is in excellent condition. There are very few defects except a few longitudinal cracks. A defect was noted in the wearing surface of the road where it passes over a culvert. A concrete slab was used at this point and is very badly worn, making rather unpleasant riding. It would seem desirable in all cases of culvert construction to carry the road surfacing clear across the culvert and thereby make for more uniform wear. It also would seem good practice to reinforce the concrete base across the approaches to culverts of this character.

ROADS NEAR STERLING, ILL.

FAILURE OF BRICK PAVEMENT, SAND CUSHION CONSTRUCTION, GOSHEN, IND.

On the Lincoln Highway east of Sterling there is a re-pressed brick road on a gravel base. It is 16 feet wide and 4 miles long. The joints are filled with tar. A great deal of the tar has flowed out of the joints into the ditches at the sides. The edges of the brick do not seem to be well protected, as the joints are not completely filled. Although built on a gravel base and carrying fairly heavy traffic there are no evidences of foundation failure.

A road 16 feet wide, constructed on a gravel base with a 1-inch cement-sand cushion and 4-inch wirecut lug brick, is part of Indian Head Trail, north of Sterling. It was laid in the summer of 1917. There is moderate traffic, with occasional heavy loads. The surface is in excellent condition, with no indications of punching through of the brick or breaking down at the sides. There are some transverse cracks, but no longitudinal. Transverse cracks occur at about the same distance as in a concrete road. The subgrade is a fine black loam and is not provided with tile drainage.

DES MOINES-CAMP DODGE ROAD.

This road is 20 feet wide and is built on a 4-inch concrete base with 4-inch wire cut lug brick on a thin sand-cement bed and has neither edging nor curb. The road was built in 1917 on a new fill in many places. The fill was placed in 1-foot layers, each rolled with a heavy roller. The traffic consists of a large number of automobiles and a considerable number of heavy trucks. The surface is in excellent condition. A careful examination of the concrete base was made in several places and it appeared to be rather weak and porous.

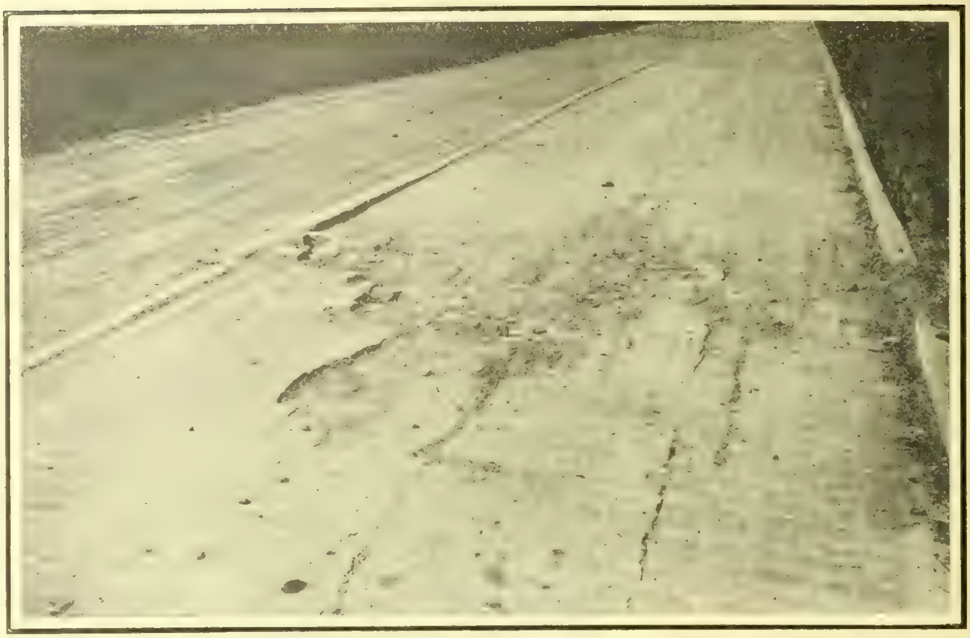
At the Des Moines end the city has put down a side-cut, lugless, brick pavement laid on a cement-sand bed, with grouted joints. The joints between these bricks are very narrow in many places and it is probable that the grout has not penetrated more than one-half inch, judging from the appearance of some defective bricks that had been removed. This road is provided with cross-expansion joints every 75 feet. At about the same time the Camp Dodge road and the lugless brick street were laid a bituminous concrete pavement was also put down. All three sections carry about the same traffic. In Camp Dodge proper there is a Portland cement concrete road and all four of these sections will, for some time in the future, be subjected to very heavy traffic leading to and through Camp Dodge. An interesting comparison of different types and construction is here furnished, and a future inspection should prove to be very instructive.

ST. LOUIS, MO.

Present practice in the construction of brick streets in the city of St. Louis makes no provision for expansion joints at street intersections. A number of semimonolithic brick streets using 1:3:6 concrete foundation and 1-inch sand-cement bed have been constructed recently along the above lines and no evidences of expansion failures at street intersections have as yet been noticed.

A semimonolithic brick street in which a type of expansion joint consisting of one course of wood block across the street every 100 feet was observed. This road has a 6-inch concrete base, 1-inch sand-cement bed for part of the way, and limestone screenings for the rest of the distance, and 4-inch brick. The use of limestone screenings in place of sand in the cushion is an improvement over the old standard construction in that there is much less likelihood of the cushion pushing up into the joints when the brick are rolled. Subsequently a number of streets were built, using this construction.

The oldest brick street in St. Louis was observed on Euclid Avenue and found to be in good condition, although laid about 25 years ago. Traffic on this street, however, is not heavy at present. The joints are sand filled.



FAILURE OF BRICK PAVEMENT, SAND CUSHION CONSTRUCTION, GOSHEN, IND.

A brick intersection laid in December, 1915, on the north and south road as a demonstration of semi-monolithic construction is in the form of a cross with three arms 200 feet long and the other 360 feet long. All but the outer 160 feet of the long arm was built on a 4-inch concrete base, using 4-inch brick. The outer 160 feet was laid on a 2-inch concrete base. The traffic on this road is very heavy and has caused a number of local failures, such as longitudinal cracks, transverse cracks, brick spalling at the joints, broken brick, etc. The surface is very badly broken up, a condition particularly noticeable at the extreme end of the section. An analysis of this failure indicates that it is due primarily to poor grouting combined with an inferior quality of brick. The appearance of the longitudinal crack would likewise indicate that some settlement had possibly taken place. This condition emphasizes very strongly the necessity of properly filling the joints in the brick with grout, thereby forming a truly monolithic surface. This undoubtedly would have protected the brick and to a certain extent would have prevented the breaking up which was observed. It was suggested at the time that a much better penetration of the grout would have been secured by the use of a modern machine grout mixer instead of the old-style box mixer which was used. This experiment clearly demonstrates what may be expected to happen to a brick pavement subjected to heavy traffic when all the details of construction are not very carefully observed.

NORTH ALTON, ILL.

An example of light monolithic brick pavement was inspected at North Alton, Ill. A short section of road 12 feet wide was laid on the main highway leading north from Alton. The construction was 4-inch brick laid on a 2-inch 1: 4 sand-cement bed, with no concrete base or edging. There appeared to be no evidences of foundation failure, in spite of the very light base. The condition of the brick and of the grouted joints was likewise good. This is a very good example of the possibilities of light monolithic construction under favorable conditions of subsoil and drainage.

KANSAS CITY, MO.

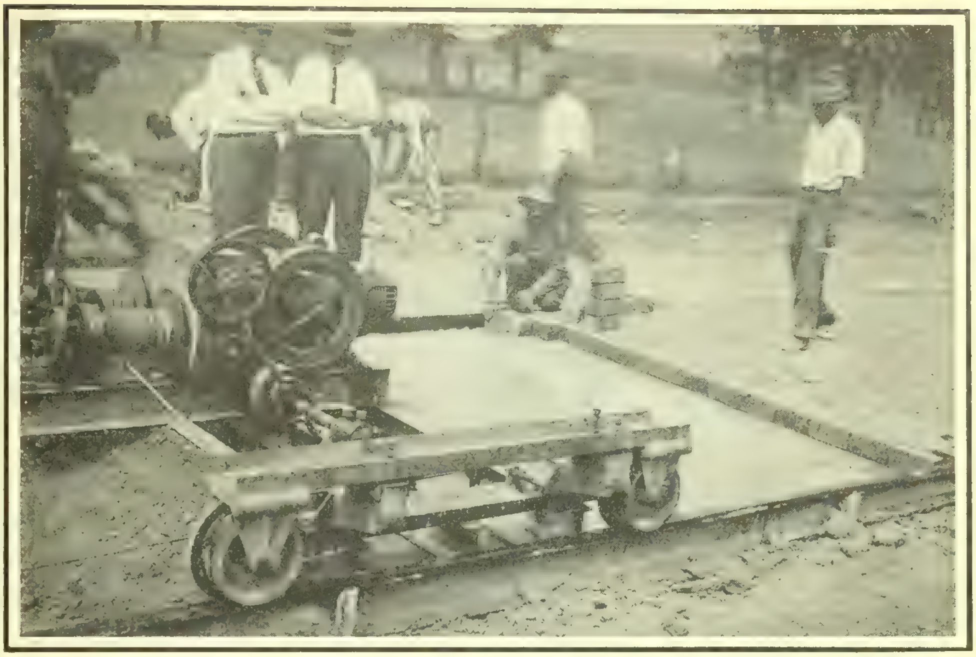
An instance of rather poor grout penetration was observed in Kansas City on old Twenty-fourth Street, which carries very heavy traffic, consisting principally of horse-drawn and motor trucks hauling from railroad yards. The pavement is laid on an 8-inch concrete base and consists of vertical fiber lug brick on sand cushion. The pavement is in fairly good condition in spite of the heavy traffic. Small local failures due to spalling of the brick were observed. That this condition was due to poor grout penetration was borne out by an inspection of a number of brick which had been taken out to make a cut. Very few brick showed evidence that the grout had penetrated to a depth greater than one-third that of the brick.

On Roanoke Road there is an example of the use of an asphalt filler. This pavement was laid on an 8-inch concrete base, with sand cushion and 4-inch vertical fiber-lug brick. The asphalt was squeegeed into the joints, the excess being allowed to flow over the surface of the pavement so as to form an asphalt wearing mat or carpet, which entirely covers the brick. This road is 5 years old and the asphalt mat is still adhering in spots. In other places it has worn away entirely exposing the brick. About the only evidence of failure observed on this road was a certain amount of wear on the brick, due probably to the impact of traffic on the unprotected edges.

Another example of an asphalt-filled pavement was noted on Thirty-ninth Street. This pavement likewise was laid on an 8-inch concrete base, using 4-inch vertical fiber-lug block on a sand cushion. The street has been down three years and, except for the fact that the asphalt does not appear to be adhering to the joints very well, is in good condition.

An instance of the use of lugless vertical fiber block with an asphalt filler was observed on Prospect Avenue. This street is about 1½ years old. The joints of the brick in this case had apparently been very poorly filled, due either to an attempt to use the filler at too low a temperature or to the fact that the spaces between brick were not wide enough. This resulted in an excess of asphalt on top in some places, while in others such filler as originally found its way into the joints has been pulled out by traffic.

On Vine Street, from Twenty-fifth to Twenty-seventh, there was a job under construction. This was of lugless vertical fiber block on an 8-inch concrete base with 1-inch sand cushion and cement grout filler. The principal feature of interest about this job was the extremely poor manner in which the brick were being laid. An inspection of the joint on a single course showed the space between courses to vary from nothing to as much as an inch. It is obvious that proper grouting under these conditions would be impossible.



TAMPING TEMPLATE FOR MECHANICALLY PREPARING CONCRETE BASE TO RECEIVE BRICK WITHOUT THE USE OF SAND-CEMENT BED.

LINCOLN, NEBR.

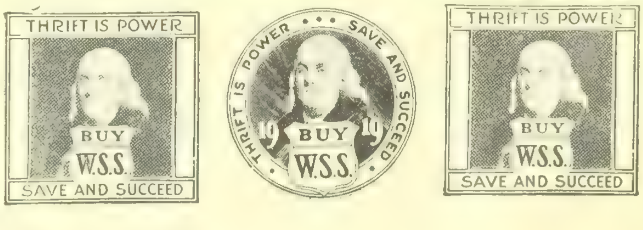
A number of asphalt-filled brick streets and roads in and around the city of Lincoln, Nebr., presented outstanding features that may be summed up as follows: They range in age from 3 to 7 years, and are, for the most part, laid on a 5-inch concrete base, composed of 1 part cement and 6 parts of fine local gravel 1 inch sand cushion and vertical fiber-lug block. As in Kansas City, the hot asphalt, ranging in temperature from 350 to 450° F., is squeegeed into the joints and considerable excess allowed to flow over the surface of the street which, with a sand covering, forms a wearing mat or carpet which remains intact for some time. The most interesting example of this construction was found on South Street west from Tenth. This street is 7 years old and is subjected to very heavy traffic. It is in excellent condition, with the asphalt mat still adhering in spots. On the exposed portions of the brick surface an examination failed to show any appreciable wear at the joints of the brick. This is one of the best asphalt-filled brick streets examined.

OMAHA, NEBR.

A number of streets inspected in Omaha include some old sand-filled streets, such as the Dodge Road, which are still in good condition. These are laid for the most part on a 5-inch concrete base, using repressed block. The modern streets are practically all asphalt-filled vertical fiber brick. The lugless vertical fiber brick are now being tried under the assumption that the kiln marks and warping of the brick may be utilized instead of lugs to form the proper spaces between the brick courses. They have not been in service long enough to form any conclusions as to their practicability. An isolated example of the use of an old lugless block was shown at Twenty-second and Chicago Streets. This is a brick street laid about 18 years ago on an old concrete base. The brick were building brick size without lugs, laid on edge, and filled with a 1:1 cement mortar grout. This street is in very good condition, the grout giving every indication of having penetrated properly. The traffic is not heavy. Inasmuch as the grout spaces appear to be very uniform it is to be presumed that considerable care was used in forming the joints.

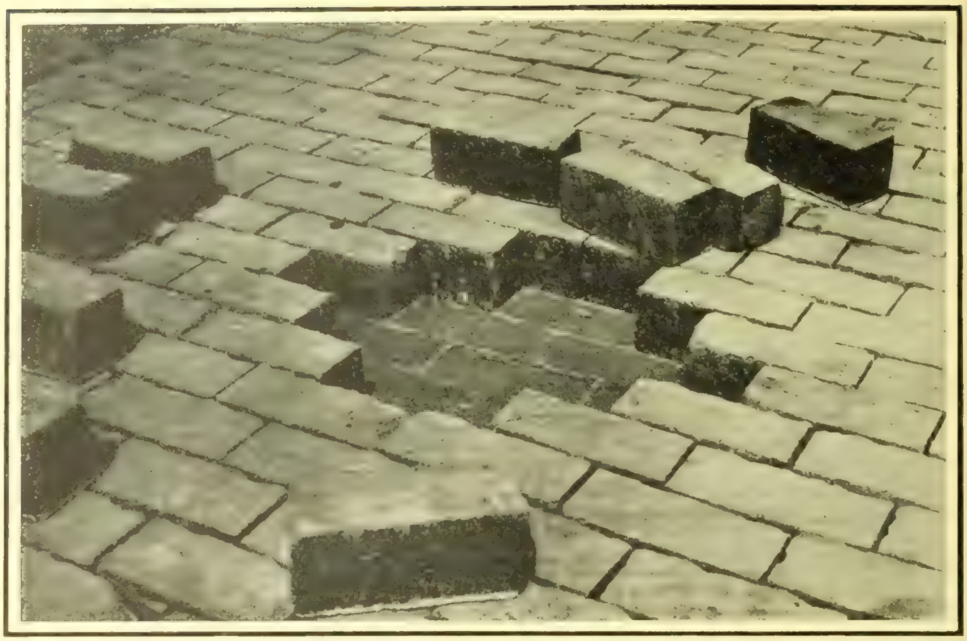
GENERAL DISCUSSION.

Unfortunately the inspection did not include examples of brick pavements having a bituminous mastic filler. The following discussion, which does not include this type of construction is based upon the observations made by the authors during this



inspection as well as upon the experiences of engineers and contractors who have done a great deal of work along this line.

The brick road considered as a structure divides itself into (1) the foundation or subgrade; (2) the base course; (3) the cushion or bedding course; (4) the brick wearing course; and (5) the joint filler, and a general discussion of all brick roads naturally lends itself to a discussion of these various divisions.



SHOWING JOINT BETWEEN BRICK AND CONCRETE BASE. MONOLITHIC BRICK ROAD CONSTRUCTION, PARIS, ILL.

TYPE OF FOUNDATION OR SUBGRADE.

In a very large number of the roads inspected there were to be observed many evidences of foundation or subgrade failures, and the importance of a study of subsoil conditions was very forcibly impressed on the writers. It has been pointed out that a great many longitudinal cracks were observed, and these occurred on fills where there was apparently good drainage, as well as in localities where the drainage was obviously bad. The character of the soil seemed to play a very important part in influencing the number of longitudinal cracks, and it was very evident that sticky, clay soils that would retain a large amount of moisture and undoubtedly show considerable heaving during freezing and thawing weather were much more likely to produce longitudinal cracks than were the more porous, sandy soils. Specific instances of brick pavements in the city of Conneaut, Ohio, some laid on a sandy foundation, and others on a clay foundation, have already been noted—those on the clay foundation having cracked and heaved, those in the sandy part of the town having remained intact. Throughout the sections visited the same general condition existed.

It can not be too strongly urged that a thorough study must be made of the underlying soil and the drainage conditions before attempting to design a road for a particular locality. It should be noted also that certain kinds of soils are not susceptible of drainage by the methods ordinarily practiced, using tile drains and French drains along the side of the road. It is apparent that capillarity plays a very strong part in influencing the retention of moisture by the subgrade, even though apparently good drainage facilities are provided. A thorough study of capillarity and methods of draining various kinds of soils would be of great benefit.

Instances have been cited, notably in the Cleveland-Akron road, in which the superimposed loads were such that the subgrade, softened by the presence of moisture, readily gave way and was unable to support the slab which, in turn, did not possess sufficient strength to act as a beam but was broken through in spots. It is possible that soils of this character could be improved very greatly in their bearing value by the use of a porous filling material, such as cinders, broken stone, slag, or gravel, and in this way the high-unit pressures transmitted directly through a pavement would be so distributed that the unit pressure on the natural soil foundation would be within the bearing value of the soil. It is also possible that correct methods of drainage might accomplish the same end, that is, increase the bearing value of the soil by drying it out.

It has been suggested that as an aid to such drainage measures a treatment of bituminous material might be beneficial. An instance of the value of a filling of porous material and of good drainage may be noted in the case of Goodfellow Avenue in St. Louis, where telford drains were placed at the side of the road and a subbase of cinders used under the broken stone wearing surface. There are no instances of foundation failures in this road, although it carries considerable traffic. It has been suggested that a good method of increasing the bearing value of the soil is to provide blind drains along the sides of the road with frequent outlets, so that the water table will be lowered considerably below the wearing course, notwithstanding the effects of capillarity.

TYPE OF BASE.

The object of the base of a brick pavement is so to properly support the wearing surface that it will maintain its original contour and not become depressed in spots or wavy. It is perfectly obvious that the character of the subsoil, which supports the foundation, and the character of the loading transmitted through the wearing course to the foundation, should control this design. Thus, one would not expect that there would be a necessity for a heavy concrete foundation if the subbase were always exceedingly firm and unyielding. On the other hand, if the subgrade were exceedingly soft, such as obtains in clay saturated with moisture, a thick base is obviously necessary in order to properly distribute heavy loads to the subgrade and reduce the unit pressure within the bearing value of the subgrade.

From these considerations it should be plain that it is perfectly possible that a wearing surface of brick laid directly on the soil might remain in very good condition if the traffic is not very heavy and if the subbase is well drained and therefore firm and unyielding under all conditions. Instances of such construction have been noted, such in Cleveland, Ohio, and Sterling, Ill., and other cases of an exceedingly light concrete base from one to two inches thick have been noted at Danville and North Alton, Ill. A number of other instances have been pointed out in which the brick surfacing has been laid on a rolled slag or a rolled stone foundation and has proven to be highly satisfactory.

OBJECT LESSON IS APPARENT.

The object lesson furnished by these roads is that the character and thickness of the base should be very largely governed by the local soil and traffic conditions. It should be emphasized very strongly that it can not be considered good practice to make a standard design for a brick road and apply this design to all sections of the country irrespective of these local conditions.

It is the practice in various sections of the country to build a brick wearing surface upon an old macadam road used as a foundation, and in a number of instances the brick wearing surface is wider than the old macadam road. Failures of the brick surface laid upon such roads have been noted, such, for instances, as occurred at Dixon, Ill., in which the sides of the brick road settled in spots due to the settlement of the new macadam foundation. Had the macadam foundation settled uniformly, trouble of this character could have been avoided, so that, unless the macadam is given uniform compaction, it is to be expected that future settlement will be unequal.

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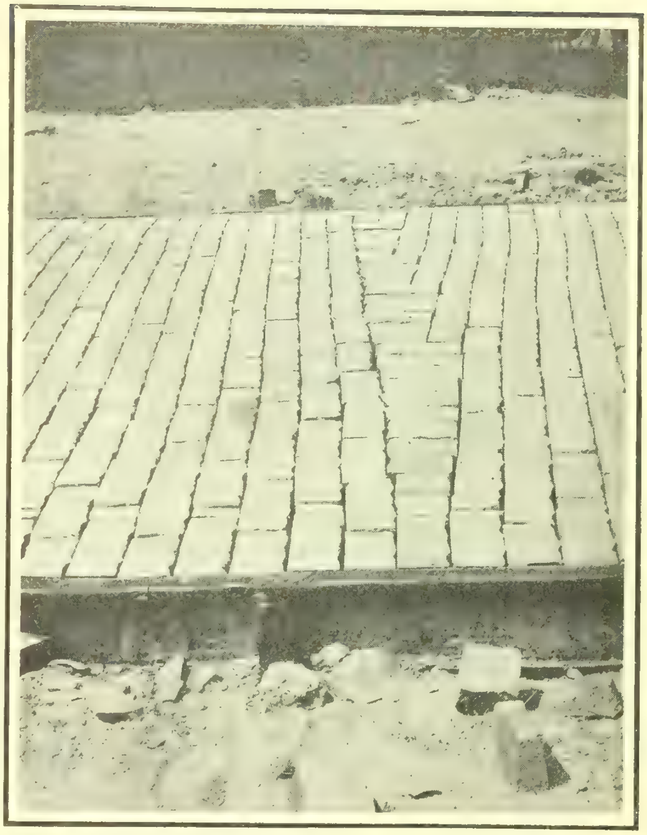


METHOD OF LAYING BRICK ON A CURVE. WIRE-CUT LUG BRICK READY FOR GROUT. PARIS, ILL.

It is the opinion of the authors that when an old macadam road is used as a foundation it is advisable to plow up the old surface and reroll it as evenly as possible, especially when the new surface is wider than the old. This applies particularly to an old road surface which is badly rutted and pitted or the crown of which must be changed to make it suitable for the brick wearing course. In some cases it might be economical to resurface the old macadam with a cement-sand bedding course, making it no thicker than is necessary to produce the proper crown. Attention has been called to the use of an old brick pavement as a foundation course for new wearing surface. Such practice seems to have worked out very successfully when a cement-sand bed was used, as evidenced by the roads at Danville, Ill.

FOUNDATION OF THE ROAD.

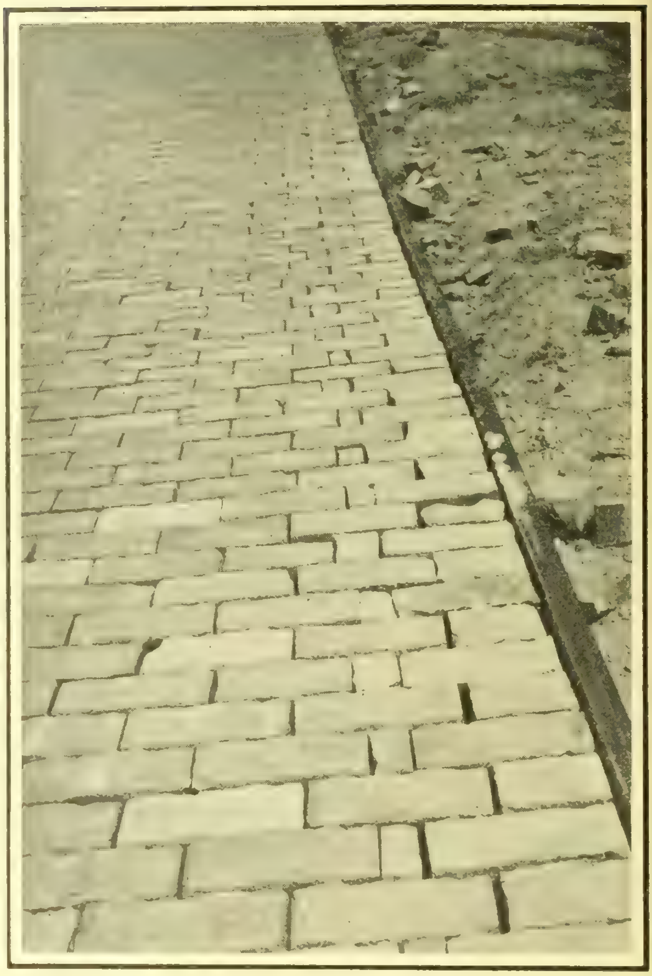
Since the foundation plays the part of distributing the load to the subbase, it is obvious that where the subbase is soft and the traffic heavy, the greatest possible distribution of load must be obtained, and this can be accomplished best by the use of a concrete base, since its resistance to bending aids in distributing the load. The proper thickness of a concrete base has been a mooted question. In certain types of brick construction, there is no doubt that the wearing surface adds to the slab strength of the concrete base, and thus aids in reducing the unit pressure on the subbase. Such a condition is true in the case of strictly monolithic construction, to a lesser degree in semimonolithic, and still less in sand-cushion construction.

A discussion of the design of a concrete base is impossible from a theoretical standpoint at the present time, in view of the fact that the exact distribution of the reaction against the under side of the slab is unknown, and will have to be determined by suitable tests. The distribution of this reaction determines the bending moment under the load and, as has been pointed out, the soil conditions greatly influence this distribution. At the present time, therefore, a determination of the proper thickness of concrete base for different types of brick roads must be based on precedent. It would seem from the results of observations that the present-day heavy traffic can be carried safely on a 4-inch concrete base with 4-inch brick wearing course when monolithic construction is used, and when the subgrade conditions are favorable. It would seem highly desirable that the thickness of this base be increased along any stretches of the road in which the subbase conditions might be open to question. On very heavily traveled city streets the thickness of the concrete base will likewise have to be increased.

Where a sand-cement cushion is used, although it is not believed that such construction is a true monolith, a 4-inch concrete base should prove sufficient under heavy traffic, provided this base is increased in thickness over bad spots in the subgrade. When sand-cushion construction is used with a grouted brick surface, a 6-inch concrete base should give good results under heavy traffic, with an increase in thickness over the soft spots in the subgrade. If a bituminous filler is used in the brick-wearing surface, theoretically the concrete base should be thicker than in the case of a grouted surface. In the absence of test data, however, it is impossible to state how much thicker.

TYPE OF CUSHION OR BEDDING COURSE.

In the old standard type of construction a cushion of sand or other fine material up to 2 inches thick was advocated, the idea of this cushion being to permit laying the brick to a smooth surface and also to give a cushioning effect for the traffic. When sand is used as a cushion it generally is brought to a level surface by rolling and the brick are placed on this cushion and rolled down with a light roller. The effect of this rolling in a number of instances has been to force the sand cushion up into the joints between the brick and thus the space which should be occupied by joint filler is partially filled with sand. In a number of sand cushion brick pavements, this has had a very detrimental effect in that when expansion takes place in the brick in hot weather, most of the compressive stress is thrown toward the top of the pavement and results in buckling, in the crushing of the top surface and the cracking or scaling of the brick. This is one very serious defect in sand cushion construction with cement grout-filled brick.


METHOD OF BATTING IN WIRE-CUT LUG BRICK AT SIDES OF PAVEMENT READY FOR GROUT, PARIS, ILL.

It is inevitable that moisture must find its way down through any cracks in the brick to the underlying sand cushion, and the amount of moisture in all probability is very much larger in the vicinity of transverse and longitudinal cracks in the brick surface than under that part of the pavement which has remained intact. Sand has the well-known property of expanding when it absorbs as high as about 10 per cent of moisture, and due to this action there is a probability that the brick surface is caused to bear unequally on the sand cushion unless the sand cushion is caused to shift its position. Again, in those parts of the sand cushion containing the greatest amount of moisture the expansion due to freezing will be greatest. Then, too, under the vibration of traffic and the movements of the concrete base and brick surfacing, due to expansion and contraction, the sand cushion undoubtedly is caused to shift its position.

INDIAN HEAD TRAIL LOOKING NORTH FROM STERLING, ILL. THIS ROAD WAS LAID ON A GRAVEL BASE. NOTE THE ABSENCE OF CONCRETE CURB.

The washing away of the sand cushion from under the brick, leaving it unsupported, is not an infrequent occurrence. The possible cushioning effect of the sand cushion becomes of minor importance in view of its many disadvantages in other respects.

DEVELOPMENT OF MONOLITHIC TYPE.

In order to eliminate some of the bad features of sand cushion construction, a semimonolithic or cement-sand bed construction was introduced. In this type of pavement a mixture is made of about 4 parts of damp sand to 1 part of Portland cement, and this is used in place of the plain sand cushion, the brick being placed and rolled on this as on the old standard type of construction. After the brick are rolled they are well wet down so that water will impregnate the sand-cement bed thoroughly, thus causing it to harden. Such construction provides most of the advantages of the sand cushion type with none of its disadvantages. It permits the brick to be brought to a smooth surface without the danger that the cushion will shift its position or come up between the joints during rolling. Moreover, there is a considerable bond between the brick surface and the concrete base, at least so far as shearing is concerned, and a stronger pavement is the result.

A further development in the monolithic type of construction has been adopted, in which the cushion or bedding course is omitted altogether. In this type of construction the brick are laid directly on the green concrete and rolled to a smooth surface. Portland cement grout then is applied preferably before the concrete base has set up. In this way a considerable adhesion is developed between the brick and the concrete base. There has been some question regarding the efficiency of this adhesion and particular pains were taken during the present inspection to gain evidence on this point. A number of pavements were examined at the sides in order to see if there was any evidence of separation between the brick and the concrete, and in no case could such evidence be found. This would seem to indicate that such construction usually is really "monolithic."

In conversation with several engineers having considerable experience with this type of construction, conflicting opinions were obtained. In general, however, it can be said that a considerable bond does exist between the brick and the concrete, provided the grouting immediately follows the laying of the brick. It is the opinion of the authors that a more truly monolithic construction is obtained when the concrete base is tamped so as to bring a thin coat of mortar to the surface and the brick laid in this mortar bed. It is believed that this flush coat or mortar works its way up into the vertical joints between the bricks and thus adds greatly to the horizontal shearing strength between the brick and the concrete. At this plane, or in its vicinity, the horizontal shear is greatest.

It often has been questioned whether or not the original bond between the brick and the concrete will be retained after several years of traffic. It has been stated that the vibration due to traffic and unequal expansion of brick and concrete will tend to loosen the bond, and in this way the supporting power of the original monolithic slab will be no greater than that of the two separate slabs of concrete and brick. This would seem to be an argument in favor of increasing the bond between the concrete base and the brick just as much as possible.

TYPE OF BRICK.

Until the year 1911, practically the only type of paving brick in use in this country was the so-called standard repressed brick with lugs molded on one side and the edges rounded. It was claimed orig-

DETAIL OF FAILURE, EXPERIMENTAL SEMIMONOLITHIC BRICK INTERSECTION LAID ON A 2-INCH CONCRETE BASE IN 1915 AT ST. LOUIS, MO.

inally that the appearance and shape of a brick were not only improved, but the density and strength were likewise increased in the process of repressing. In 1910 a type of brick was introduced in which the lugs were wire cut on the sides and repressing was omitted, the brick going directly from the wire cutter to the drying ovens. Inasmuch as the repressing was omitted, the edges of the wire-cut lug brick were square instead of rounded.

A recent development in the type of brick used is the so-called vertical fiber lug brick which differs from the older wire-cut lug type in that the brick are laid in the pavement with the wire-cut surface up instead of on the side. The lug on the vertical fiber brick is produced in the process of forcing the clay through the die, the upper side of which is cut in the shape of the lug desired. This forms what is known as a "bar" lug. It is usually about 1 inch wide and there are ordinarily four lugs on each brick.

Since wire-cut lug brick were first introduced they have gained greatly in popularity, especially when used in conjunction with a cement grout filler. Many manufacturers, as well as engineers, have reached the conclusion that the process of repressing adds nothing to the strength or density of a paving brick. The rounded edge of the repressed brick furthermore appears to be a detriment rather than an advantage when used with grout filler, as the grout is more apt to hold to the square-edged brick than where the edges are smooth and rounded. Numerous instances were noted of grout-filled repressed brick streets where the grout had been ground out of the brick to the depth of the rounded edge. On the other hand, in wire-cut lug grouted brick pavements the grout in the brick appeared to wear down evenly, so that the surface remained smooth and continuous.

Vertical fiber brick with cement grout filler have hardly been in use long enough to draw any definite conclusions regarding the advantages which have been claimed for them. Such observations as the authors were able to make would indicate that a number of objections to their use with cement grout might exist. Most important of these is the fact that the lugs, being rectangular, touch the adjacent brick over a considerable area instead of at points or lines as in the other types of lug brick. Cement grout can penetrate only the spaces between the lugs, leaving, in the case of the vertical fiber brick, a relatively large area of the sides of the brick over which no adhesion to the adjacent brick is possible. It would seem hardly possible under such conditions to obtain as truly a monolithic bond as exists where practically the entire space between the courses is filled with grout. As before stated, in monolithic and semimonolithic construction, the side bond between the brick should be as strong as possible, in order to protect the bond between the brick and the base. Vertical fiber lug brick were intended primarily for use with bituminous fillers and are now successfully used in this way to a considerable extent in Kansas City, Mo., and Lincoln and Omaha, Nebr.

LUGLESS TYPE OPEN TO CRITICISM.

Experience with the lugless type of vertical fiber brick has been confined almost entirely to Kansas City, Mo. Such observations as were made would indicate that the use of this type of brick was open to serious criticism in that unless great care is used in laying, unequal spacing will result. This was illustrated forcibly in construction work under way in Kansas City. The condition shown in the illustration, while typical of this particular job, is an extreme one. It should be possible to lay lugless brick in much straighter courses than are here shown. It would ordinarily seem reasonable to suppose, however, that a better job of setting would result if lug brick were used, because greater care in selection is necessary in the case of lugless brick if uniform joints are to be obtained. This is due to the fact that in the lugless brick, warping and kiln marks which vary with individual brick are depended upon to form the grout spaces.

ROANOKE ROAD, KANSAS CITY, MO. BITUMINOUS-FILLED BRICK PAVEMENT ON 8-INCH CONCRETE BASE. NOTE THE SURFACE MAT WHICH HAS BEEN FORMED AS THE RESULT OF USING AN EXCESS OF BITUMINOUS FILLER.

Advocates of the lugless bricks maintain that uniformity of the grout spacing is not essential to good construction. This opinion, it seems to the authors, is not well founded in view of the fact that wherever the sides of the brick come into actual contact, as they often do if not spaced carefully by hand, no penetration of grout or filler will be possible. This results in a greatly weakened side bond and permits water to leak through the joints. The first brick pavements built were of the lugless type, but great care was exercised by those in charge of construction to insure uniformly spaced joints. Lugs were introduced simply to insure this spacing automatically. It would seem extremely unwise to run the chance of failure through imperfect grouting simply in order to avoid the use of lug brick. The work already started in Kansas City and that being started in Omaha will be watched with interest.

JOINT FILLERS.

Among the older streets of many cities in the Middle West are still to be found brick pavements with sand-filled joints. While the majority of these streets are rough and uneven, due both to the cobbling of the individual brick and to unequal settlement of the foundation, a large number still were in fairly good condition. Practically all were laid on the natural soil foundation. Possessing no slab strength, these sand-filled streets conformed to the contour of the foundation under all conditions, so it is not surprising that after 18 or 20 years they are somewhat uneven. The principle disadvantage of sand as a filler, assuming a stable and unyielding soil condition, is that it does not protect the edges of the brick from chipping out under the action of the traffic. It is more difficult to keep such a street clean, and water is sure to wash down through the joints into the sand bedding course.

The most widely used filler for brick pavements at the present time is Portland cement grout. It has the advantage, if properly applied, of producing practically a monolithic slab capable of resisting bending stresses. On the other hand, this slab, when subjected to temperature changes, expands and contracts like any other monolithic structure, resulting in cracks due to contraction and bulges or heaving due to expansion. Expansion failures usually occur, as would be expected, at the top of vertical curves, or at any other place where for one reason or other the pavement is crowned transversely. Contraction cracks manifest themselves always by the cracking of the grout, usually in a straight line across the road, and ordinarily occur about as far apart as on a concrete road. On account of the greater resistance to abrasion of brick over concrete the contraction cracks in brick roads do not wear nearly as rapidly as in concrete roads, and are, therefore, not as serious a maintenance consideration.

Provision for expansion sidewise against curbs always is made by inserting some form of bituminous joint either poured or prepared, between the brick and the curb or gutter. Provision for expansion longitudinally usually is made in the case of city streets at intersections, while in the case of country highways transverse expansion joints usually are omitted, except under special conditions.

TRANSVERSE JOINTS.

There is apparently some difference of opinion regarding the necessity of transverse joints on both city streets and country highways. In sections where numerous expansion failures have occurred, those in charge of construction are either advocating the use of bituminous fillers exclusively or else regularly spaced transverse expansion joints. The former attitude is illustrated by experience in such cities as Lincoln and Omaha, Nebr., and the latter by the experience in Vermillion County, Ill. A number of types of joints have been tried, such as courses of wood block, as noted in St. Louis, spaced about 75 or 100 feet apart, or courses of bituminous filled brick spaced about the same distance. In other sections where little expansion trouble has developed engineers seem to prefer to run the chance of an occasional blowup rather than risk excessive wear at joints.

Observations made by the authors would indicate that for city work transverse expansion joints should be installed at street intersections in at least one direction across the intersection and in both directions if the intersection is crowned; while for highways they may be omitted except in special cases, such as curves at the intersections of very long tangents and at abrubt changes in grade. Joints not over one-fourth inch in thickness seem to give the best results.

Although there is considerable opposition to the general use of bituminous fillers for brick pavements, good results in using asphalt have been obtained in certain cities west of the Mississippi as has been previously noted. The prinicipal disadvantage of bituminous fillers appeared to be the lack of protection afforded the brick at the joints; moreover they do not give any slab strength to the brick surface. The former fact was noted in a number of cases on old bituminous filled streets in which the edges of the brick have worn badly. The relative action of traffic on bituminous filled and grout filled joints was noted on those streets where expansion joints consisting of a number of courses of bituminous filled brick had been installed. The difference in wear was very noticeable.

Another disadvantage of bituminous fillers is the tendency, particularly noted in tars, of running out at the sides of the road in hot weather or chipping in cold weather. They possess still another disadvantage of requiring constant attention at the time of application to insure that the temperature of the bituminous material remains at the proper point; since, if too cold, they will bridge the joints instead of penetrating, and, if too hot, they will become hard and inert. On the other hand, they possess the undoubted advantage of being free from expansion troubles. They likewise make a somewhat quieter pavement.

The ease of making service cuts in city streets through this type of pavement is another advantage.

It should be emphasized that when a bituminous filler is used particular care should be taken in its selection in order to avoid the troubles incident to ill-suited materials. In those asphalt filled streets examined in the cities west of the Mississippi, it was noted that by the use of considerable excess of bituminous material a wearing mat of appreciable thickness was formed over the surface of the brick pavement. This mat apparently remains for some years, depending upon its thickness and the character and volume of traffic, and while still intact undoubtedly protects the brick from the action of traffic to a very large extent. This probably is the reason brick streets in this section have worn so little.

CONCLUSIONS.

The authors have drawn the following conclusions as a result of their study of brick pavements:

1. The type and thickness of base for any brick pavement should depend upon (*a*) the maximum weight of the loads to be carried, and (*b*) the bearing value, under all weather conditions, of the underlying soil.
2. In all cases where the traffic to be carried is likely to be heavy or where the underlying soil is of such a nature that its bearing value is not sufficient to support the pavement under all conditions, a concrete base of sufficient thickness to properly distribute the loads should be provided.
3. Where the maximum weight of the loads to be carried is not excessive and the subsoil is of a porous well-drained nature, the thickness of the concrete base may be decreased or under very favorable conditions, it may even be omitted altogether.
4. Other things being equal a somewhat lighter construction may be permitted in the case of the "monolithic" and "semimonolithic" types than where the ordinary sand cushion type is provided, on account of the increased slab strength which these types appear to possess.
5. A concrete curb or edging is not necessary when "monolithic" or "semimonolithic" construction is used.
6. Paving brick with well-formed contact lugs are to be preferred to brick without lugs.
7. Paving brick with square edges are to be preferred to brick with rounded edges.
8. Given the requisite care in construction, satisfactory results may be obtained with either cement grout or bituminous filler.
9. Vertical fiber lug brick with bituminous filler have given good service in those cities west of the Mississippi where they were inspected, possibly due to the protecting action of the asphalt mat which prevents wear from coming upon the brick irect.
10. Expansion joints in grout filled pavements would seem advisable at street intersections and at points of tangency on curves, and longitudinal joints should be used against all rigid curbs or structures.

LUGLESS VERTICAL FIBRE BRICK READY FOR GROUT, VINE STREET, KANSAS CITY, MO., SHOWING THE POOR MANNER IN WHICH BRICK WERE LAID.

APPORTIONMENT OF FUNDS AVAILABLE UNDER FEDERAL-AID LAW AND THE AMENDMENT THERETO.

THE Post Office appropriation bill for the fiscal year 1920 as passed contains the roads amendment increasing the amount of Federal-aid funds by $200,000,000 and funds for forest reservation roads by $9,000,000. It also broadens the definition of a rural post road, and raises the limit of Federal contribution from "not to exceed $10,000" to "not to exceed $20,000 a mile." The apportionment of funds now available for Federal-aid roads among the States is as follows:

States.	Amount available for fiscal years 1917, 1918, 1919.	$50,000,000 additional fiscal year 1919.	Totals for fiscal year 1919.	Fiscal year 1920 allotment.	Fiscal year 1920 additional $75,000,000.	Fiscal year 1920 totals.	Fiscal year 1921 allotment.	Fiscal year 1921 additional $75,000,000.	Totals for fiscal year 1921.	Grand total.
Alabama	$625,903.17	$1,050,264.10	$1,676,167.27	$420,105.64	$1,575,396.15	$1,995,501.79	$525,132.05	$1,575,396.15	$2,100,528.20	$5,772,197.26
Arizona	411,081.14	685,043.57	1,096,124.71	274,017.43	1,027,565.36	1,301,582.79	342,521.79	1,027,565.36	1,370,087.15	3,767,794.65
Arkansas	498,085.77	840,229.53	1,338,315.30	336,091.81	1.260,344.30	1,596,436.11	420,114.76	1,260,344.30	1,680,459.06	4,615,210.47
California	909,358.99	1,524,248.30	2,433,607.29	609,699.32	2,286,372.45	2,896,071.77	762,124.15	2,286,372.45	3,048,496.60	8,378,175.66
Colorado	508,349.34	867,570.90	1,375,920.24	347,028.36	1,301,356.35	1,648,384.71	433,785.45	1,301,356.35	1,735,141.80	4,759,446.75
Connecticut	185,487.77	307,064.65	492,552.42	122,825.86	460,596.98	583,422.84	153,532.32	460,596.98	614,129.30	1,690,104.56
Delaware	48,965.10	81,384.45	130,349.55	32,553.78	122,076.68	154,630.46	40,692.22	122,076.68	162,768.90	447,748.91
Florida	338,652.69	573,797.20	912,449.89	229,518.88	860,695.80	1,090,214.68	286,898.60	860,695.80	1,147,594.40	3,150,258.97
Georgia	806,897.89	1,346,044.75	2,152,942.64	538,417.90	2,019,067.12	2,557.485.02	673,022.38	2,019,067.12	2,692,089.50	7,402,517.16
Idaho	363,862.05	610,509.27	974,371.32	244,203.71	915,763.91	1,159,967.62	305,254.64	915,763.91	1,221,018.55	3,355,357.49
Illinois	1,321,102.17	2,185,550.65	3,506,652.82	874,220.26	3,278,325.97	4,152,546.23	1,092,775.32	3,278,325.97	4,371,101.29	12,030,300.34
Indiana	813,473.04	1,349,919.40	2,163,392.44	539,967.76	2,024,879.10	2,564,846.86	674,959.70	2,024,879.10	2,699,838.80	7,428,078.10
Iowa	873,180.41	1,443,046.20	2,316,226.61	577,218.48	2,164,569.30	2,741,787.78	721,523.10	2,164,569.30	2,886,092.40	7,944,106.79
Kansas	858,754.08	1,436,313.93	2,295,068.01	574,525.57	2,154,470.89	2,728,996.46	718,156.96	2,154,470.89	2,872,627.85	7,896,692.32
Kentucky	585,400.35	976,865.17	1,562,265.52	390,746.07	1,465,297.76	1,856,043.83	488,432.59	1,465,297.76	1,953,730.35	5,372,039.70
Louisiana	406,179.27	680,729.03	1,086,908.30	272,291.61	1,021,093.55	1,293,385.16	340,364.51	1,021,093.55	1,361,458.06	3,741,751.52
Maine	290,161.92	481,231.35	771,393.47	192,492.62	721,847.33	914,339.95	240,615.78	721,847.33	962,463.11	2,648,196.53
Maryland	263,013.09	434,737.02	697,750.11	173,894.81	652,105.53	826,000.34	217,368.51	652,105.53	869,474.04	2,393,224.49
Massachusetts	442,814.70	736,883.30	1,179,698.00	294,753.32	1,105,324.95	1,400,078.27	368,441.65	1,105,324.95	1,473,766.60	4,053,542.87
Michigan	872,707.53	1,447,213.80	2,319,921.33	578,885.52	2,170,820.70	2,749,706.22	723,606.90	2,170,820.70	2,894,427.60	7,964,055.15
Minnesota	853,047.58	1,420,774.53	2,273,822.11	568,309.81	2,131,161.80	2,699,471.61	710,387.26	2,131,161.80	2,841,549.06	7,814,642.78
Mississippi	535,469.12	899,488.26	1,434,957.38	359,795.31	1,349,232.39	1,709,027.70	449,744.14	1,349,232.39	1,798,976.53	4,942,961.61
Missouri	1,017,765.21	1,695,314.11	2,713,079.32	678,125.64	2,542,971.14	3,221,096.78	847,657.05	2,542,971.14	3,390,628.19	9,324,804.29
Montana	593,382.46	999,467.15	1,592,847.61	399,786.86	1,499,200.73	1,898,987.59	499,733.58	1,499,200.73	1,998,934.31	5,490,771.51
Nebraska	639,757.68	1,066,642.07	1,706,399.75	426,656.83	1,599,963.10	2,026,619.93	533,321.04	1,599,963.10	2,133,284.14	5,866,303.82
Nevada	386,424.72	642,933.45	1,029,358.17	257,173.38	964,400.18	1,221,573.56	321,466.72	964,400.18	1,285,866.90	3,536,798.63
New Hampshire	125,599.97	207,810.38	333,410.35	83,124.15	311,715.57	394,839.72	103,905.19	311,715.57	415,620.76	1,143,870.83
New Jersey	354,995.26	594,050.80	949,046.06	237,620.32	891,076.20	1,128,696.52	297,025.40	891,076.20	1,188,101.60	3,265,844.18
New Mexico	474,847.98	798,785.78	1,273,633.76	319,514.31	1,198,178.67	1,517,692.98	399,392.89	1,198,178.67	1,597,571.56	4,388,898.30
New York	1,501,835.01	2,487,956.40	3,989,791.41	995,182.56	3,731,934.60	4,727,117.16	1,243,978.20	3,731,934.60	4,975,912.80	13,692,821.37
North Carolina	685,702.23	1,139,977.47	1,825,679.70	455,990.99	1,709,966.20	2,165,957.19	569,988.74	1,709,966.20	2,279,954.94	6,271,591.83
North Dakota	458,015.09	768,360.27	1,226,375.37	307,344.11	1,152,540.42	1,459,884.53	384,180.14	1,152,540.42	1,539,720.56	4,222,980.46
Ohio	1,118,759.68	1,854,462.47	2,973,222.15	741,784.99	2,781,693.71	3,523,478.70	927,231.24	2,781,693.71	3,708,924.95	10,205,625.80
Oklahoma	691,906.34	1,153,055.50	1,844,961.84	461,222.20	1,729,583.25	2,190,805.45	576,527.75	1,729,583.25	2,306,111.00	6,341,878.29
Oregon	472,394.85	787,459.10	1,259,853.95	314,983.64	1,181,188.65	1,496,172.29	393,729.55	1,181,188.65	1,574.918.20	4,330,944.44
Pennsylvania	1,382,078.29	2,296,075.85	3,678,154.14	918,430.34	3,444,113.77	4,362,544.11	1,148,037.92	3,444,113.77	4,592,151.69	12,632,849.94
Rhode Island	69,969.51	116,530.95	186,500.46	46,612.38	174,796.43	221,408.81	58,265.48	174,796.43	233,061.91	640,971.18
South Carolina	430,437.00	717,297.05	1,147,734.05	286,918.82	1,075,945.58	1,362,864.40	358,648.52	1,075,945.58	1,434,594.10	3,945,192.55
South Dakota	486,013.67	810,720.68	1,296,734.35	324,288.27	1,216,081.02	1,540,369.29	405,360.34	1,216,081.02	1,621,441.36	4,458,545.00
Tennessee	683,123.95	1,132,103.50	1,815,227.45	452.841.40	1,698,155.25	2,150,996.65	566,051.75	1,698,155.25	2,264,207.00	6,230,431.10
Texas	1,752,770.13	2,926,219.37	4,678,989.50	1,170.487.75	4,389,329.05	5,559,816.80	1,463,109.69	4,389,329.05	5,852,438.74	16,091,245.04
Utah	341,613.62	567,592.10	909,205.72	227,036.84	851,388.15	1,078,424.99	283,796.05	851,388.15	1,135,184.20	3,122,814.91
Vermont	136,662.33	225,987.70	362,650.03	90,395.08	338,981.55	429,376.63	112,993.85	338,981.55	451,975.40	1,244,002.06
Virginia	597,102.90	992,052.95	1,589,155.85	396,821.18	1,488,079.43	1,884,900.61	496,026.48	1,488,079.43	1,984,105.91	5,458,162.37
Washington	432,183.03	722,367.25	1,154,550.28	288,946.90	1,083,550.87	1,372,497.77	361,183.62	1,083,550.87	1,444,734.49	3,971,782.54
West Virginia	319,525.27	532,009.10	851,534.37	212,803.64	798,013.65	1.010,817.29	266,004.55	798,013.65	1,064,018.20	2,926,369.86
Wisconsin	767,790.41	1,272,946.53	2,040,736.94	509,178.61	1,909,419.79	2,418,598.40	636,473.26	1,909,419.79	2,545,893.05	7,005,228.39
Wyoming	367,396.24	612,912.45	980.308.69	245,164.98	919,368.68	1,164,533.66	306,456.22	919,368.68	1,225,824.90	3,370,667.25
Total	29,100,000.00	48,500,000.00	77,600,000.00	19,400,000.00	72,750,000.00	92,150,000.00	24,250,000.00	72,750,000.00	97,000,000.00	266,750,000.00
Administration	900,000.00	1,500,000.00	2,400,000.00	600,000.00	2,250,000.00	2,850,000.00	750,000.00	2,250,000.00	3,000,000.00	8,250,000.00
Grand total	30,000,000.00	50,000,000.00	80,000,000.00	20,000,000.00	75,000,000.00	95,000,000.00	25,000,000.00	75,000,000.00	100,000,000.00	275,000,000.00

INCREASED HIGHWAY WORK SHOWN BY RECORD OF FEDERAL-AID PROJECTS.

IN December and January a total of 128 Federal-aid projects were approved or went to final agreement. While the number of the projects was small in December there was a big increase in January. The record for that month in the amount of Federal-aid allowed and the estimated cost of construction is the largest month's record since the Federal-aid law was enacted. A total of $3,066,185.32 Federal-aid allowance is called for in the 98 projects in the list for that month.

In December the total allowance was only $795,301.69. Four allowances were made for roads in Alabama, all sand-clay, the total amounting to $38,217.95. Four projects in Nevada were considered, two of which were approvals and two allowances. Three North Carolina projects were approved and two reached final agreement. Three projects in Ohio which went to final agreement were allowed $112,195, the largest allowance to any one State. The largest allowance for a single project was $89,878.71, for 11.19 miles of concrete road in Maryland, estimated to cost $179,757.43.

In January Michigan was given the largest total allowance, $533,098.30, for six projects, for 90.279 miles of gravel and macadam, graded earth, gravel surface treated macadam and concrete roads having an estimated cost of $1,115,692.79. Montana led in the number of projects—eight. They were for six gravel roads and two bridges, with a total estimated cost of $330,118.08 and a Federal-aid allowance of $110,469.65. The four Nebraska projects considered, all of which went to final agreement, for earth and sand-clay roads, showed the greatest mileage, 148.53. The estimated cost of the four is $272,298.95, and the allowance $137,993.42.

A single road in Delaware, 11.5 miles long, of concrete, is estimated to cost $537,827.40. The allowance was only $20,000. Missouri, for two roads 27.5 miles long, receives an allowance of $136,149.47, while Illinois for two roads, 30.38 miles long, estimated to cost $781,404.86, will receive $308,193.36. These are concrete and bituminous macadam roads. Louisiana came next to Montana in the number of projects considered, with seven, all gravel roads, with a total estimated cost of $323,473.44 and an allowance of $147,456.95. Iowa followed with six projects, estimated to cost $382,364.86 and an allowance of $106,706.77

RECORD OF FEDERAL AID PROJECTS IN DECEMBER, 1918.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama.	3	Clay	9.11	Sand-clay		Dec. 21	$20,662.73	$10,331.36
	4	Pike	8.71	do		do	20,064.58	10,032.29
	5	Covington	7.27	do		Dec. 19	20,003.50	10,001.75
	6	do	2.00	do		Dec. 11	15,685.10	7,842.55
Arkansas	22	Lafayette	6.95	Gravel	Dec. 4		48,950.95	22,205.52
Louisiana	24	Ouachita	4.82	do	Dec. 11		25,560.70	12,500.00
	25	do	7.00	do	do		44,697.15	15,000.00
	28	Iberia	8.59	do	do		46,255.22	22,000.00
Maryland	7	Baltimore and Harford	11.19	Concrete		Dec. 4	179,757.43	89,878.71
Michigan	12	Iosco	4.75	Gravel		do	54,963.23	27,481.61
Mississippi	39	Marshall	4.25	do	Dec. 26		49,632.00	24,816.00
Missouri	13	Buchanan	2.20	Asphaltic		Dec. 11	42,822.32	21,401.16
Nebraska	5	Madison and Platte	48.00	Earth and sand-clay		Dec. 4	104,455.50	52,227.75
Nevada	3	Churchill	7.61	Sand-clay		Dec. 7	70,707.78	35,353.89
	4	Douglas	4.00	25 per cent macadam, balance graded earth.		do	9,885.70	4,942.85
	11	Esmeralda	8.90	Earth	Dec. 19		38,330.49	19,165.24
	13	Nye	25.00	do	Dec. 17		40,700.00	20,350.00
New York	14	Chautauqua	7.67	Concrete and brick	Dec. 4		152,800.00	76,400.00
North Carolina.	21	Pender	7.675	Top soil		Dec. 7	26,998.08	5,000.00
	27	Orange	17.70	Top soil or sand-clay	Dec. 16		33,000.00	12,000.00
	28	Lee	12.05	Gravel	Dec. 4		27,933.95	10,000.00
	32	Edgecombe	3.10	Sand-clay or gravel		Dec. 4	14,088.65	7,000.00
	35	Forsyth	1.87	Concrete	Dec. 4		60,335.87	26,400.00
Ohio	14	Williams	2.69	Reinforced concrete		Dec. 21	90,700.00	19,295.00
	16	Clark	4.93	Concrete or bituminous macadam.		do	137,100.00	49,300.00
	17	do	4.46	Bituminous macadam		do	119,000.00	44,600.00
South Carolina	13	Lexington-Richland		Bridge over Broad River	Dec. 4		44,868.18	22,434.09
South Dakota	10	Clark	14.29	Gravel	Dec. 16		44,143.83	19,932.70
Texas	65	Fisher	23.00	do		Dec. 26	93,525.05	46,429.19
Wisconsin	38	Marathon	8.09	do		Dec. 4	44,940.09	14,980.03
Total	30		277.875				1,718,568.08	795,301.69

RECORD OF FEDERAL AID PROJECTS IN JANUARY, 1919.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed	Estimated cost.	Federal aid allowed.
Alabama	35	Pike	6.00	Sand-clay		Jan. 25	$20,433.43	$10,216.71
Arizona	5	Mohave	2.184	Grading	Jan. 12		50,930.00	21,840.00
California	9	San Diego	15.00	Concrete		Jan. 8	273,498.03	121,913.95
Colorado	4	Garfield and Rio Blanco	21.00	20 miles surfaced with stone or gravel, balance graded earth.		Jan. 14	[1] 84,012.83	42,006.41
Delaware	2	Sussex	11.516	Concrete		Jan. 16	537,827.40	20,415.10
Georgia	15	Coweta	3.64	Top soil or sand-clay		Jan. 31	20,219.72	7,000.00
	32	Columbia	9.715	do		Jan. 9	19,833.40	9,000.00
Idaho	7	Custer	18.00	Graded earth		Jan. 11	[2] 79,233.96	37,000.00
Illinois	1	Dupage, Kane, Dekalb, Ogle, Lee, and Whiteside.	15.92	Bituminous macadam resurfacing and concrete		Jan. 4	395,898.41	160,175.26
	2	Kankakee and Iroquois	14.4643	Concrete and bituminous macadam.		Jan. 29	385,506.45	148,018.10
Iowa	25	Blackhawk	4.08	Brick and asphalt or concrete	Jan. 29		126,066.16	21,881.28
	30	Winnebago	7.50	Gravel	Jan. 10		47,437.50	15,425.14
	32	Des Moines	2.82	Brick or concrete	Jan. 20		52,195.00	16,584.93
	33	Clark	9.60	Earth	Jan. 3		58,170.00	16,546.27
	41	Floyd	11.72	Gravel	Jan. 4		75,396.20	19,136.45
	42	Wapello	10.80	Earth	Jan. 14		40,370.00	16,932.90
Kansas	2	Labette	10.159	Gravel or macadam		Jan. 17	115,837.65	17,375.65
	11	Sedgwick	7.375	Concrete		Jan. 18	274,289.97	41,143.50
	20	Johnson	6.00	Bituminous macadam	Jan. 10		65,033.32	9,754.99
	21	Allen	3.25	Concrete and macadam	Jan. 21		52,338.28	7,850.74
Kentucky	5	Mercer	5.00	Earth	Jan. 4		42,909.47	21,954.73
	10	Larue	6.50	Water-bound macadam	Jan. 16		41,547.00	20,773.50
Louisiana	15	Avoyelles	5.41	Gravel		Jan. 27	59,036.67	25,000.00
	16	East Baton Rouge	4.90	do		Jan. 22	35,913.90	17,956.95
	18	Caldwell	2.40	do		Jan. 27	11,462.99	5,000.00
	24	Ouachita	4.82	do		Jan. 7	25,560.70	12,500.00
	25	do	7.00	do		Jan. 7	44,697.15	15,000.00
	28	Iberia	8.59	do		Jan. 7	46,255.22	22,000.00
	29	Franklin	10.47	do	Jan. 25		100,496.81	50,000.00
Massachusetts	10	Norfolk	2.42	Bituminous	Jan. 18		73,123.05	24,200.00
Michigan	1	Muskegon and Oceana	19.864	Gravel and macadam	Jan. 7		333,982.00	166,991.00
	3	Baraga	48.15	Graded earth		Jan. 31	342,878.60	171,439.30
	7	Alcona	5.972	Gravel		do	78,153.19	39,076.50
	25	Delta and Schoolcraft	8.108	Surface treated macadam	Jan. 21		144,485.00	72,242.50
	27	Charlevoix	5.707	Concrete	Jan. 18		139,700.00	57,070.00
	34	Washtenaw	2.478	Concrete or bituminous	do		76,494.00	26,280.00
Minnesota	2	Chisago	31.50	Gravel		Jan. 7	205,962.80	80,000.00
	27	Douglas	16.00	do		Jan. 17	90,833.31	25,000.00
	34	McLeod	9.10	do		Jan. 16	33,321.97	15,000.00
Mississippi	30	Lauderdale	7.70	do	Jan. 30		41,184.00	20,000.00
	33	Tunica	4.03	Clay-gravel		Jan. 16	37,884.05	12,500.00
	42	Osyka	9.90	Gravel	Jan. 2		71,500.00	35,000.00
Missouri	15	New Madrid	19.50	do	Jan. 22		130,245.50	65,122.75
	16	Salina	8.00	Asphaltic macadam	Jan. 29		142,053.45	71,026.72
Montana	14	Park		Bridge	Jan. 14		33,231.00	16,615.50
	18	Custer	4.00	Gravel	Jan. 22		22,000.00	11,000.00
	19	do	4.00	do	do		22,000.00	11,000.00
	23	Blaine	4.00	do	do		20,004.60	10,002.30
	24	do	5.00	do	do		15,397.80	7,698.90
	30	Broadwater		Bridge	Jan. 11		65,092.50	32,546.25
	31	Park	3.60	Gravel	Jan. 22		21,903.20	10,951.60
	32	do	3.00	do	do		21,310.20	10,655.10
Nebraska	14	Holt and Boyd	42.00	Earth and sand-clay	Jan. 31		83,875.00	41,937.50
	22	Custer	35.00	Earth	Jan. 16		75,900.00	37,950.00
	27	Dodge and Sanders	31.53	do	Jan. 12		50,050.00	25,025.00
	29	Butler	40.00	do	Jan. 16		70,161.85	33,080.92
Nevada	10	White Pine	16.50	do	Jan. 18		94,000.50	47,000.25
	12	Lyon	2.40	Earth and gravel	Jan. 7		9,515.00	4,757.50
	14	Douglas	3.00	Gravel	Jan. 20		19,554.00	9,777.00
	17	Lyon	6.25	do	Jan. 29		36,916.00	18,458.00
New Hampshire	13	Grafton	1.61	do		Jan. 14	15,806.45	7,903.22
	18	Hillsborough	.90	do		Jan. 13	9,070.05	4,535.02
	19	Cheshire	.60	do		do	9,128.84	4,564.42
New Mexico	8	Chaves	7.00	Macadam		Jan. 18	73,787.78	36,893.89
	13	Valencia	28.90	Gravel and sand-clay	Jan. 12		163,933.00	81,966.50
	14	Santa Fe	10.65	Gravel	Jan. 10		74,547.00	37,273.50
New York	12	Cortland	6.54	Bituminous macadam	Jan. 18		130,800.00	65,400.00
North Carolina	20	Yadkin	6.41	Top soil		Jan. 22	25,146.00	8,000.00
	36	Durham	7.482	Concrete and sand-clay	Jan. 29		193,054.05	23,000.00
	37	Gaston	10.405	Bituminous macadam	6an. 21		174 222.18	12,000.00
	40	Union	4.287	Sand-clay or gravel	Jan. 17		10,230.00	4,000.00
North Dakota	25	Ward	5.00	Gravel	Jan. 17		7,128.00	3,564.00
	33	McIntosh	15.00	Earth	Jan. 21		18,000.00	9,000.00
	34	Emmons	15.00	do	Jan. 31		20,000.00	10,000.00
	37	Hettinger	19.00	do	Jan. 24		20,669.00	10,334.50
	38	do	9.50	do	do		19,240.00	6,046.88
Oregon	13	Grant	7.20	Gravel		Jan. 14	143,817.00	71,908.57
South Dakota	3	do	11.83	do		Jan. 11	26 963.39	13,481.69
	9	Brown	12.60	do	Jan. 21		72,424.00	36,212.00
	11	Union	9.04	do	Jan. 4		41,283.00	16,412.70
Tennessee	6	Washington	21.349	Macadam	Jan. 22		287,709.67	143,854.82
Texas	2	Brooks	20.10	Sand-clay or gravel		Jan. 18	[4] 65,248.80	30,500.00
	7	Mitchell	7.50	Gravel		Jan. 7	40,268.00	20,134.00
	26	Titus	7.26	Bituminous gravel	Jan. 16		45,354.89	14,010.00
	34	Dickens	6.50	Gravel	do		38,979.00	15 345.00
	41	Tarrant	10.80	Bituminous gravel		Jan. 14	66,630.78	32 628.43
	42	do	7.513	do		do	18,029.79	9,014.90
	61	Wichita	4.68	do		Jan. 22	48,518.57	12,500.00
	76	Galveston	5.50	Shell	Jan. 23		19,827.50	8 600.00
Vermont	10	Rutland	4.30	Gravel	Jan. 21		64,262.00	32,131.00
Virginia	17	Hanover and Carolina		Bridge		Jan. 22	23,099.86	11 549.93
	26	Surry and Prince George	4.05	Gravel	Jan. 21		54,778.15	[illegible]
	28	Henry	3.73	Topsoil	Jan. 22		33,486.42	16 743.21
Washington	9	Douglas	5.28	[illegible]		Jan. 22	37,976.44	18 750.00
	13	Okanogan	1.077	Bridge		do	33 178.64	13 789.67
West Virginia	25	Lincoln	[illegible]	Concrete	Jan. 16		59 062.50	25 000.00
	26	do	6.00	do	Jan. 18		78 750.00	10 000.00
Wisconsin	54	Adams	5.75	Sand-clay	Jan. 22		35 823.75	11,941.25
Total	98		954.3853				[illegible]	[illegible]

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[1] Revision. Estimated cost increased from $78,314.43 and allowance from $39,415.71, previous agreement; in previous agreement.

[2] Revision. Allowance increased from $25,000.

[2] Revision. Estimated cost increased from $289,950.22 and allowance from $141,975.31.

[4] Revised agreement. Estimated cost increased from $[illegible] and allowance from $20,000.

OPERATIONS OF BUREAU OF PUBLIC ROADS UNDER THE FEDERAL-AID ROAD ACT.

By P. ST. J. WILSON, Chief Engineer Bureau of Public Roads.

(Address at convention American Road Builders' Association, Feb. 25, 1919.)

WHEN the Federal-aid road act was passed in 1916 it provided not merely a substantial Federal appropriation to help meet the expense of road construction; it went further and sought to develop in the several States a spirit of self-help in the matter of road improvement and to strengthen the policy of State highway control. These purposes, greater in their ultimate benefit than the granting of money aid, have been and are being accomplished in the respective States so thoroughly as to indicate in the fullest measure the wisdom of the framers of the Federal act.

It is generally admitted that only through an efficient State highway department with broad powers and ample funds can any State reach the maximum of accomplishment in road building and maintenance. The requirement of the Federal act that each State could cooperate only through a highway department gave a powerful impetus to the policy of State highway management. At the time the first Federal apportionment was made 17 States were without highway departments within the meaning of the act. To-day every State has a highway department fully meeting the requirements of the act. The assent of all the States has been given, together with a pledge of good faith to cooperate with the Federal Government throughout the life of the Federal measure.

LAW'S EFFECT ON STATE PROGRAMS.

To the end that haphazard road building should not be permitted, the Secretary of Agriculture at the outset asked each State to submit a program or scheme showing what the State contemplated doing under the joint plan. This each State has done and as an outcome of such orderly planning there has come about a strengthening of State highway departments, an appropriation of funds, and a designation of specific State systems of highways as to give the brightest promise for an early and satisfactory working out of our own problems. I shall not burden you with a list of the measures adopted by the several States as a result of the Federal-aid road act, as such a list will include nearly all of the 48 States. I might cite, however, the well-balanced and effective State highway system designed by Wisconsin following the passage of the Federal act, the designation of a specific State highway system in Virginia, the laying out of a trunk-line system in Illinois, as examples of the constructive efforts on the parts of the States to correlate their efforts with those of the Federal Government while working out their own problems to the best advantage.

At the outset of this great cooperative undertaking it was found necessary to harmonize and provide uniformity to some degree at least in the matter of surveys, plans, and specifications for Federal-aid roads. This was brought about through conferences with State officials, with the same success as was obtained in regard to the broader questions of legislation and administration. State standards as to plans and specifications have been submitted for Federal-aid road work in 39 States, and we shall soon have this phase of the question on a routine basis for all of the States.

DELAY CAUSED BY THE WAR.

All of this far-reaching preliminary work, required as it was specifically by the terms of the act or by the necessary regulations issued under authority of the act, took a good deal of time, and when we began to find the ground cleared sufficiently to show prospects of actual road building we were in the midst of the mightiest war in the world's history. We could not take railroad cars, fuel, labor, and money from the supreme test of defeating the Hun save only where the diversion of such forces had a direct bearing upon the winning of the war and served that purpose greater than would the purpose from which the labor, transportation, fuel, or money was withdrawn. Thus road building slowed down and finally, in the summer of 1918, it almost came to a standstill. There were grumblings and mutterings and much honest criticism of the restrictive policy in regard to road work. How much of it was justified no one will ever know. Such communities, however, as had gone on for years with the roads they had, and suddenly thought it necessary to begin their building operations at the particular moment when the fate of the world hung in the balance, could hardly have just ground for expecting that their needs should be met at the expense of munition making, shipbuilding, or other direct war operations. Doubtless some roads were delayed which should have been built, but, however that may be, the point I am chiefly interested in impressing on you is that, due to war conditions, the actual physical benefits of the Federal-aid road act were delayed at least a year.

I am glad to say, however, that with our preliminary work all done, with the throttling influence of war removed, with the mighty stimulus of a blending of public spirit and public need we are on the threshold of the greatest road building era the world has ever known.

FEDERAL AID RECORD TO DATE.

In order that you may know just what we have accomplished in regard to individual Federal-aid projects and just what we anticipate, I may say that to the close of February 21, 1919, a total of 841 projects had been approved by the Secretary of Agriculture, involving a total estimated cost of $61,333,454.94, of which Federal aid was called for to the amount of $23,203,112.41. These projects aggregate 8,615 miles in total length, and involve every recognized type of construction, this being due to our policy of trying to meet the individual needs in the light of the local conditions in each State and locality. You understand, of course, that the approval of projects does not mean necessarily that they are ready for actual construction. Surveys must be made and plans, specifications, and estimates prepared and approved for each project before the construction can be started. In many cases, the plans, specifications, and estimates are ready at the time the application is approved, but in many other cases they are not submitted in satisfactory form until a long time after such approval.

Of the total number of projects approved 434 had reached the stage at the close of February 21, where the plans, specifications, and estimates had been approved so that construction might actually begin. These projects carried a total estimated cost of $30,111,226.79, of which amount $11,663,086.85 consisted of Federal aid. The total mileage of the projects thus made ready for construction was 3,586 miles. On January 31, 316 projects were actually under construction or completed, involving a total estimated cost of $22,672,233 and Federal aid to the amount of $8,382,067.

PRESENT ROAD BUILDING PROGRAM.

That you may understand the scope and extent of our road building program for this year, I would state that the total amounts apportioned to the several States, after deducting 3 per cent for administrative purposes, aggregate $29,100,000 for the fiscal years 1917, 1918, and 1919, this period ending June 30 of this year. An additional $19,400,000 becomes available July 1, making the total apportionment for the four years $48,500,000. Deduct from this the amount of approximately $8,500,000, referred to above, and we may say there are $40,000,000 of Federal funds to apply to this year's projects. As the States must provide at least an equal amount, you can see that there will be a minimum of $80,000,000 for Federal projects if all of the Federal money under existing appropriations is met. As a matter of fact, the States have been putting up in the past a little over 60 per cent of the cost of Federal projects, and if this policy continues, the amount available for Federal-aid roads would run over $100,000,000. To this amount must be added the forest road appropriations which are averaging about $1,300,000 per annum of Federal funds, making available for this class of work, including local funds, approximately $2,600,000.

In discussing the Federal-aid program I have not thus far taken into account the appropriations carried by the amendment to the Post Office bill. This amendment, as you probably know, carries an appropriation of $50,000,000 to become immediately available, $75,000,000 to become available July 1, of this year, and $75,000,000 to become available July 1, 1920. Thus it provides for this calendar year an additional $125,000,000, and if this is met dollar for dollar by the States, it means $250,000,000 added to the $80,000,000 I have already mentioned, or a total of $330,000,000, including administration. The forest road appropriation under the new amendment is $3,000,000 for the fiscal year 1919 and $3,000,000 for each of the following fiscal years, so that it would mean an additional $6,000,000 for forest roads this year. I do not know whether the States will be able to meet this tremendous appropriation, but it is a stirring call to them to rise to the great task of doing a double duty, first, of providing needed public improvements; and second, of meeting the great problem of unemployment.

LAW PROVED BY EXPERIENCE.

It is rare in the history of legislation that any particular measure has been able to stand the acid test of its practical application without developing any weak points. It was to be anticipated that the Federal aid act would in course of time indicate a need for amendment in some particular. The Federal aid act has developed comparatively few weaknesses. The most serious, however, has been the requirement as to the post route status of each project. It has been exceedingly difficult to hold on the one hand the Federal aid improvement to a definite well connected program, and on the other hand to confine the improvements to roads on which mail routes were established or in reasonable prospects of being established. As you no doubt know, rural delivery routes follow very irregular courses in the endeavor to reach the individual patrons and it is, of course, absurd to build an important highway along such meandering routes. Furthermore, in some of the Western States, which are yet in process of development, Federal aid projects comprised long stretches of highway on which no mail routes were established and which would only depend upon the contingencies of the future for securing mail facilities along with the other benefits of well-organized and enlightened communities. This restriction in the Federal act has undoubtedly delayed and very much hampered the accomplishment of practical results. An amendment, therefore, in the post office bill this year is highly essential to the effective administration of the Federal aid act and it is hoped will remove one of the chief existing obstacles.

When Congress put a limitation of $10,000 per mile in the allotment of Federal aid to individual projects they had in mind that where cities were building expensive boulevards, the Federal money should not by any chance be restricted in its usefulness by becoming absorbed in the construction of a few miles of a purely local utility. Since the act was passed, a tremendous increase in the cost of all products and all efforts has made the $10,000 limitation a hindrance rather than a help to the work, and so the provision in the Post Office bill to raise the limit of Federal aid to $20,000 per mile is just one more shackle removed.

It is a striking tribute to the effectiveness of the act that no other amendment, looking to any change in the existing measure, has been found necessary.

PROCEDURE UNDER THE LAW.

We are trying very earnestly to find ways and means of shortening the present procedure for the approval of projects and for accomplishing the various steps necessary before actual construction can be undertaken. I wish to emphasize, however, that cooperation of the State highway departments is essential to the accomplishment of this purpose, and that while we may, by cutting out some intermediate stops, materially shorten the time which we take in putting a project through, our actual records show that relatively a very great delay is due to the failure of the State highway departments to promptly submit plans, specifications, and estimates, to execute agreements and to carry out the steps plainly set forth in the rules and regulations.

I have heard the opinion expressed that the Government held too rigidly to the requirement of substantial types of construction and thorough engineering. We find in our practical application of the Federal aid road act that it is impossible to establish a hard and fast standard for the entire United States. In some of the poorer and more sparsely settled States the requirement of costly and substantial types of construction will be equivalent to withholding the benefits of the Federal aid road act from the people, while in thickly settled territory where traffic is heavy we must insist upon types of construction amply sufficient to withstand the traffic conditions. Our engineering requirements are consistently held to a point below which inefficiency would result, but here again we try to make the requirement elastic enough to prevent an undue burden upon those States and communities whose needs are slight and whose means are less. I believe by following a "give and take" policy we shall get the utmost benefit out of the Federal aid road act, and I feel that as State highway departments are given more and more authority and facilities by the respective State legislatures, they are becoming more and more able to handle the Federal aid work as well as their other State work with such a degree of efficiency as to require little more than a routine superinspection, and a sort of moral support on the part of the Federal Government.

The underlying principle of the whole Federal measure is cooperation and if we who represent the Federal Government and those who represent the State governments continue to deal with each other in accordance with that fundamental principle, I feel sure that we shall have no troubles that are not easily capable of solution.

MINNESOTA STATE TRUNK ROADS.

The Minnesota Legislature has enacted a law adopting the system of State trunk highways proposed by State Highway Commissioner Babcock and providing for a constitutional amendment permitting the issuance of road bonds by the State, not to exceed $10,000,000 in any year, the interest and sinking-fund charges to be raised by the tax on automobiles and motor trucks.

MOTOR-TRUCK REGULATION.

A measure to regulate motor-truck traffic in Pennsylvania which will probably become a law at the present session of the legislature fixes 24,000 pounds as the maximum weight of loaded trucks, 25 feet as the maximum length, and 8 feet as the maximum width. It requires all municipalities to enact the same speed and crossing rules.

FOR HORSE TRAFFIC.

The New York State grange at its annual meeting in February adopted a resolution asking for a driveway for horse, of suitable footing, and wide enough to accommodate a wagon, along all State highways. There is much interest throughout the country looking to the proper provision for wagon traffic in the improvement of roads.

EFFICIENCY OF BITUMINOUS SURFACES AND PAVEMENTS UNDER MOTOR-TRUCK TRAFFIC.

By PREVOST HUBBARD, Chemical Engineer, United States Bureau of Public Roads.

(Presented at Convention of the American Road Builders Association, Feb. 25, 1919.)

THE title of this paper covers a subject upon which a great deal of thought has been spent by progressive highway engineers as applied to prewar traffic conditions and its prospective normal development. Many engineers had, at least in their own minds, classified the various types of pavements with relation to their efficiency under ordinary variations in traffic encountered on county, State, and municipal highways and their ideas were fairly well fixed on the subject as evidenced by more or less consistent practice in their choice of types when reconstruction or new construction became necessary. Just where the dividing line should be drawn, so far as traffic is concerned, between different types of pavements has always been a matter of individual opinion, but in general with increases in volume and weight of traffic the increasing efficiency of the bituminous types has been rated as follows:

1. Bituminous surfaces.
2. Bituminous macadam.
3. Bituminous concrete.
4. Sheet asphalt and asphalt block.

Suddenly and with little opportunity for anticipation a very large mileage of our important State highways and many of our local county and municipal pavements were subjected to a tremendous increase in traffic. This increase was not only in volume, which would have presented a comparatively simple problem to solve, but in the weight and load carrying capacity of the individual vehicle. This, coupled with an unusually severe winter and immediately followed by war restrictions upon the use of many road materials, labor shortage, excessive costs, and loss of members of highway engineering organizations, created a situation during the year 1918 which was abnormally serious and complicated. With comparatively few exceptions, new construction ceased and maintenance was so handicapped as to become inadequate.

FAILURE UNDER HEAVY TRAFFIC.

Hundreds of miles of roads failed under the heavy motor-truck traffic within a comparatively few weeks or months. Roads with bituminous surfaces, bituminous macadam roads, and bituminous concrete roads all failed alike, together with other types used in State and county work. These failures were not only sudden but complete and almost overnight an excellent surface might become impassable. Such rapid and complete failures in municipal pavements were of less common occurrence, and as sheet asphalt and asphalt block have always been largely confined to municipal work failures of these types have not been noted to the same extent as the other types mentioned.

In the haste and confusion of war activities little opportunity has existed for a systematic and comprehensive study of the problem suddenly thrust upon highway engineers. Reports from all parts of the country have, however, established one outstanding fact which has a most important bearing upon any consideration of the efficiency of bituminous surfaces and bituminous pavements. A very large proportion of the failures have been characterized by an almost simultaneous destruction of the entire road structure, and not merely the disintegration of the wearing course or pavement proper. No type of pavement will be efficient unless provided with a foundation which will hold up the pavement until it is worn out. When, therefore, the entire structure fails suddenly, inadequate subgrade or foundation conditions are primarily responsible and but little basis exists for placing an efficiency valuation upon the wearing course.

CAUSES OF FOUNDATION FAILURE.

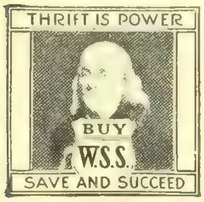
Inevitably coupled with sungrade and drainage conditions, foundation failures occurring as previously described may be due to one of two causes, lack of thickness or inability of the foundation structure to sustain the loads without appreciable internal movement. So far as bituminous surfaces or bituminous pavements are concerned remedy of the first cause does not affect the general type of construction. If, however, present heavy motor-truck traffic is to continue and possibly increase in weight as well as volume the second cause may have a direct bearing upon possible modifications in design and in the ultimate determination of the efficiency of certain classes of bituminous work. Most subgrades have a much lower carrying capacity in the spring than at other periods of the year. As there is practically no slab effect produced by the structure of a broken stone or gravel foundation, a load applied to any overlying bituminous surface is transmitted quite directly to the subgrade. In other words, the intensity of load under its point of application is relatively high throughout the foundation thickness.

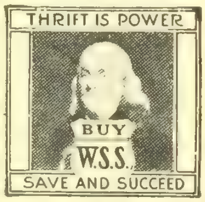
Under heavy motor-truck traffic the intensity of load transmitted through a 2-inch thickness of dense bituminous concrete to the foundation may be so great as to cause an internal movement sufficient to produce disintegration of the pavement. This is particularly true when the subgrade is of a soft or clayey nature and appears to be quite possible irrespective of any economical thickness of broken stone or gravel foundation which may be used. In general the experience on heavily traveled city streets has demonstrated the necessity of a slab foundation for any wearing course, and there appears to be no reason why such experience should not serve as a guide for new construction of bituminous pavements on State and county highways subjected to modern heavy-truck traffic. On these highways the traffic has certainly been as severe as on many city business streets, so far as weight of unit loads is concerned, and more severe when the high speed often attained by such traffic is considered.

BITUMINOUS SURFACE TREATMENT.

With respect to existing gravel and macadam roads, whether or not they have been previously surface treated with bituminous material, it would seem far safer at the present time to attempt to preserve such roads under heavy motor truck traffic by means of surface treatment with bituminous materials rather than to utilize them as foundations for the construction of new bituminous macadam or bituminous concrete pavements. In other words, for the time being such treatments may prove more efficient than the use of a higher type of pavement placed upon the existing road, although it is clearly recognized that, under heavy motor truck traffic, the bituminous pavements are more efficient, providing the foundation is adequate to support the loads.

Under the same conditions of traffic bituminous surfaces are most efficient in localities where frost action is either absent or not severe. Such treatments used in connection with gravel roads adjacent to Army cantonments in the far South have given reasonable satisfaction, even under heavy motor truck traffic. North of the frost line and particularly in connection with the treatment of clayey gravel roads which become soft during the spring months, bituminous surfaces are apt to completely disappear. If, however, the gravel road is maintained by dragging and at the end of the thawing-out period is reshaped, thoroughly compacted, and again treated with bituminous material, it may be kept in a reasonably satisfactory condition.





HEAVY MAINTENANCE COSTS.

Under very heavy motor truck traffic, however maintenance costs may be extremely high, so that if a continuation of such traffic is to be expected the construction of a new road may be necessary. Thus during a period of 120 days on a clay gravel road leading from Alexandria to Camp Humphreys, Va., which was subjected to an average daily traffic of some 230 heavy motor trucks, the cost for maintenance amounted to approximately $10,000 per mile. Because of this enormous expense the construction of a new type of road became necessary.

In connection with this road it is of interest to note that prior to its maintenance as a gravel road it had served as a 6-inch foundation for a dense bituminous concrete pavement 2 inches thick. This pavement had successfully passed a year of ordinary country and pleasure traffic, carrying a large number of touring cars between Washington and Mount Vernon. In the spring of 1918 it was suddenly subjected to an average traffic of over 200 heavy motor trucks a day, and within a comparatively few weeks was absolutely ruined, due to failure of the foundation during the thawing out period. An extension of this road in the city of Alexandria consists of a number of sections of very carefully constructed bituminous macadam laid some years ago upon a concrete base. Although subjected to the same heavy traffic, the bituminous macadam, ordinarily considered less efficient than bituminous concrete did not fail, except in a few places where failure of the concrete base could be held responsible owing to exceptionally poor subgrade conditions.

BITUMINOUS SURFACES ON MACADAM.

Bituminous surfaces on properly constructed macadam roads subjected to heavy motor truck traffic may, as a rule, be maintained in localities north of the frost line with less expense and better results than on gravel roads under the same conditions. Such surfaces, under heavy motor truck traffic, can not be considered as economical from the ordinary standpoint, but may prove the most efficient temporary method of preserving the existing road until money is available for reconstruction. It is believed, however, that under these conditions bituminous surfaces will not even prove efficient unless constantly maintained by a patrol system operating throughout the year.

Maintenance by the Bureau of Public Roads of experimental bituminous surfaces on the Rockville

Pike, Maryland, which is a macadam road, have lemonstrated that such surfaces constructed with uitable tar and oil products are efficient under easonably heavy traffic, provided the patrol system f maintenance is followed. If such a system had ot been in use during the past year when from 28 raffic counts an average of 135 motor drays, 816 notor pleasure vehicles, and 61 horse-drawn veicles per day passed over the road, it would from ll indications have been completely destroyed.

With regard to the efficiency of bituminous macadam under heavy motor-truck traffic, there are a number of points to be considered. In general, bituminous macadam has not been thought to be efficient for such traffic but, on the other hand, it has almost invariably been placed upon a broken stone or gravel base. Results obtained in the city of Alexandria, which have previously been mentioned indicate that if properly constructed and laid upon a concrete base the bituminous macadam may prove quite satisfactory.

PAY ATTENTION TO CONSTRUCTION.

Aside from character of foundation, it is believed that sufficient attention has not in general been paid to the important details of bituminous macadam construction so as to obtain best results. Too frequently the coarse stone is not sufficiently compacted before the first application of bituminous material is made, and later uniform compaction is extremely difficult, if not impossible to secure. Rutting the road with certain types of distributors just prior to application of the material is a common cause of lack of uniformity in compaction, and a strong tendency to distribute faster than the road can be satisfactorily compacted and finished by a single roller is another.

Best results from this type of road which have come under the writer's notice have been secured by the hand pouring method, although this method is considered antiquated by many engineers. Where the first application upon the thoroughly compacted coarse stone is made diagonally across the center line of the road and the second pouring or seal coat is made in a direction diagonally across the first, with proper attention to uniformity of distribution it is possible to secure a very excellent pavement, as has been repeatedly demonstrated by Mr. E. C. Dunn, city engineer of Alexandria, Va.

The efficiency of bituminous concrete, sheet asphalt, and asphalt block pavements under city traffic is so well understood as to require little comment in this paper. If laid upon suitable concrete foundations there is no reason to suppose that the results given by these pavements in city construction will not be duplicated on county and state highways subjected to heavy motor-truck traffic. If the foundation is inadequate to support the load, the pavement is bound to fail, but, as previously pointed out, failure can not then be considered a measure of the pavement proper.

MATERIALS OF CONSTRUCTION.

With regard to materials of construction a few comments may not be out of place, as the efficiency of a bituminous surface or bituminous pavement depends not only upon its method of construction but of what materials it is composed.

In general, the author's observation and experience has been that the most efficient bituminous carpets are constructed with the heaviest grade of bituminous material which it is possible to apply and make adhere uniformly to the road surface. For cold-surface treatment this will demand either a cut-back asphalt, a heavy asphaltic oil with specific viscosity of 80 to 120 at 25° C. containing an appreciable amount of volatile material that will evaporate after application and leave practically an asphalt mat residue, or the most viscous refined tar product that can be applied cold. For the latter a specific viscosity as high as 25 to 35 at 40° C. should be used if climatic conditions will permit.

While on old macadam roads it is advisable to keep the thickness of carpet under one-half inch, on certain types of soft gravel it may be of greater thickness provided a hard and tough coarse aggregate cover of sufficient size to force into the old gravel surface by rolling is used. For clay-gravel or sand-clay-gravel roads north of the frost line it is believed that for maintenance under heavy truck traffic light superficial treatment with bituminous materials applied cold will prove more efficient than the construction of a bituminous carpet, although neither will be adequate to carry the road through winter.

With regard to bituminous macadam and coarse aggregate bituminous concrete, there is little to suggest in connection with the grades of bituminous materials ordinarily used. It is believed, however, that even in the northern United States the use of an asphalt cement softer than 120 penetration or a refined tar of less than 120 second float test at 50° C. for bituminous macadam is inadvisable if modern heavy motor traffic is to be sustained. It is also believed that more attention should be given to specifying and securing a uniform size, and grading within reasonable limits, of coarse stone for bituminous macadam in order to promote uniformity in the penetration of the bituminous material as it is applied and to produce a surface that will wear as uniformly as possible. Such specifications should be based upon tests made with laboratory screens and should at least cover the permissible percentage retained on the maximum and passing the minimum diameter of screens selected, as well as the percentage limits required to pass or be retained upon an intermediate screen.

USE OF HARDER GRADES OF ASPHALT.

In connection with sheet asphalt and the fine aggregate bituminous concretes the tendency to use harder grades of asphalt cement than heretofore used may prove advisable for very heavy traffic conditions. It is quite possible, however, that better results may be secured by a reduction in the compacted thickness of such pavements with a corresponding increase in thickness of binder course where one is commonly used. For fine aggregate bituminous concretes which are commonly laid without a binder course, the introduction of such a course not less than 1½ inches thick may prove advisable with a reduction in thickness of wearing course to not more than 1½ inches. Provided the binder course is properly constructed such practice should tend to produce a pavement less susceptible to displacement under heavy motor truck traffic. In any event it is believed that even more attention should be paid to aggregate grading than heretofore in order to produce most satisfactory results.

The resistance to displacement of compacted bituminous aggregates, containing particles from one-half inch in diameter down and consisting largely of sand, is mainly dependent upon grading of the mineral aggregate and hardness of the bituminous cement. When, however, the particles become very small and possess absorptive or colloidal properties, neither grading nor consistency of the cementing medium are such important considerations. Very large surface contact and high frictional resistance then become the prime factors. Thus, a fine mastic composed of limestone dust or clay and a very soft asphalt cement may exhibit even greater resistance to displacement than a graded sand aggregate mixed with a much harder asphalt cement. The former type is exemplified by certain finely pulverized bituminous limestones. Use of the latter has but recently passed the experimental stage. It is quite possible, however, that future developments will establish such extremely fine bituminous aggregates as being highly efficient under heavy motor truck traffic for both the sheet and block type of construction.

LARGE FEDERAL-AID PROJECT.

The State highway department of Pennsylvania has just submitted the statement for one of the largest projects on which Federal aid has so far been requested. The road is located between Gettysburg and Harrisburg and has a net length of 29.9 miles. An 18-foot concrete pavement is planned for the entire route, an option of a bituminous concrete top on a concrete base being offered. The estimate of the cost as now presented is $1,315,000, which is at the rate of nearly $44,000 per mile.

Projects of this sort indicate the advancement which is being made toward the improvement of long stretches of road with the higher types of surfaces and show conclusively that the public is back of the movement for better highways.

HIGH-CLASS MARYLAND ROAD.

The State highway department of Maryland has recently submitted the project statement for 13.1 miles of concrete highway to connect Claiborne with the present concrete road running out of Easton. The reconnaissance estimate calls for an expenditure of $453,860, which is at the rate of nearly $35,000 per mile. The surfacing is to be 16 feet wide and of standard thickness and will, it is estimated, cost about $3.50 per square yard.

Only a few years ago such a price would have been considered prohibitive. Now it is accepted without question. This difference in attitude speaks volumes as to the extent to which the public at large is back of the movement toward the construction o high-class roads.

ALL WORK ON FEDERAL-AID ROADS.

In order to meet the largely increased amount o Federal aid allotted to California under the new appropriation, the California highway departmen has decided that it will be necessary to do all Stat highway work for the next three years on Federal-aid projects.

FOR COUNTY HIGHWAYS.

The 10 towns in Suffolk County, N. Y., wil have about $600,000 to spend on roads this year This amount includes that appropriated by th towns, the State-aid funds awarded by the Stat highway commission, and balances on hand i several towns from appropriations not used last year

STATE HIGHWAY MANAGEMENT, CONTROL, AND PROCEDURE

By M. O. ELDRIDGE, Assistant in Road Economics, G. G. CLARK and A. L. LUEDKE, Engineer Economists of the Bureau of Public Roads.

IN the foregoing numbers appeared the chapters on State highway management, control, and procedure. In this number are presented the chapers on 28 additional States, completing the series. Each one takes up the development and results of State participation and control of road work and he relation of State to local control; organization, personnel, duties and powers of State and local road officials; classification of State and local roads with particular reference to control and basis of payment, ncluding methods of selection, powers of State highway departments in granting aid, procedure in making surveys, letting contracts, and the control exercised by the State and local officials over road construction and maintenance; sources of State and local funds, basis of allotment and apportionment of State funds, and the relation of State to local funds, and the amount available for road purposes during the last calendar or fiscal year.

MINNESOTA.

DEVELOPMENT.

State participation in Minnesota is of very recent origin, of State-wide extent, and consists of advisory and supervisory assistance and monetary aid. State participation had its beginning with the passage of the constitutional amendment in 1897 authorizing the use of State funds for highway improvement and authorizing the establishment of a State highway commission.

The State highway commission, which was first established in 1905, has been subject to additional legislation affecting its powers and duties and personnel until at present State authority over road matters is vested in a commissioner appointed by the governor, who administers the expenditure of State and Federal funds provided for highway improvement. He has limited supervision over certain local funds, which are generally expended under the jurisdiction of assistant engineers appointed by the commissioner and who are located in the various counties of the State in charge of State highway work and such local highway work as may be delegated to them by the county or town officials.

The system of State highways, comprising 13 per cent of the total road mileage of the State, has been selected by the county boards, subject to the approval of the State commissioner of highways. This system is being improved by means of State and local funds. Approximately two-fifths of the mileage in the system of State highways as at present designated has been improved. However, this system may be amended as needed by joint agreement by the State and local officials.

During 1916 the State highway department expended $1,390,525 of State funds and exercised supervision over the expenditure of $3,337,550 of local funds. The total expenditures for the period by all road forces of the State amounted to $8,742,278. Thus the State contributed 15.9 per cent and exercised supervision over 54 per cent of all expenditures. The total expenditure from all sources during 1917 amounted to $8,024,760.

While highway improvement is carried out on an extensive scale in Minnesota, the improvements are so located as to secure the greatest benefit to the counties themselves and at the same time develop a system of main arterial highways throughout the State.

ORGANIZATION.

The organization of the highway forces of the State and their relation is shown on the diagram herewith.

State.—The State highway department is administered by a State commissioner of highways appointed by the governor for a term of six years. He appoints and is assisted by a deputy commissioner, who is required to be an experienced road builder and engineer and who is in charge, subject to the orders of the commissioner, of the technical work of the department, and by a chief engineer in charge of bridges, culverts, and special structures, a first assistant road engineer in charge of maintenance, State aid, etc., and a road-construction engineer in charge of road-construction design and Federal-aid work; also by five division engineers, who

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have general supervisory charge of road and bridge work in the various counties to which Federal and State funds are contributed.

Assistant engineers who have charge and supervision of construction and maintenance of State highways in the various counties are appointed by the commissioner. However, one or more counties may comprise the territory to which an assistant engineer is assigned. Other employees, technical and clerical, are employed by the commissioner as required by the volume of work in hand. The total expense of maintaining the State highway department is restricted to not more than 10 per cent of the State road and bridge fund, and the total expense of the central office of the department may not exceed $25,000 per year. The commissioner is required to publish general rules for the construction, improvement, and maintenance of the State roads, taking into consideration the suitability and availability of local materials to allot State funds, and to order payment thereof to the various counties of the State, to enter into contracts for maintenance under certain conditions, and to inspect annually all bridges of 30-foot span or more throughout the State.

County.—Authority over road and bridge affairs is vested in a county board consisting of five members elected for terms of four years. One member thereof is elected chairman. The county auditor is clerk and the county treasurer is fiscal agent of the board. The board has the necessary authority to levy taxes, to enter into contracts for improvement of roads and bridges on State and county highways, and to engage such agents or assistants as may be required to complete such work. The engineering work of the county is generally done by the assistant engineer detailed thereto by the State highway commissioner, and as a general rule a close and harmonious relationship exists between the boards and the engineers cooperating with them.

Towns.—The towns of Minnesota consist of an area generally identical with one or more congressional townships and are governed by a board of three supervisors elected for terms of three years. They have jurisdiction over town roads and employ an overseeer and such other forces as may be required to construct and maintain the same. The board has authority to levy taxes for and to enter into contracts relative to road construction and improvement.

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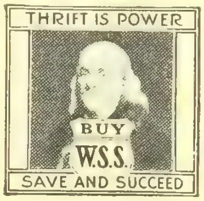

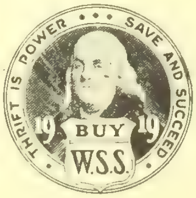

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CLASSIFICATION, CONTROL, AND PROCEDURE.

The 93,527 miles of public road in Minnesota are for the purpose of fixing responsibility for control, construction, and maintenance divided by legislative enactment into three groups, namely, State roads, county roads, and town roads.

State roads.—These comprise 12,700 miles of road selected by the respective county boards of the State with the approval of the State commissioner of highways, or by the commissioner on a petition directed to him by 10 or more freeholders. They are constructed under county administration with State and county funds. The percentage of cost borne by the State is 80 per cent in counties having an assessed valuation of less than $5,000,000, 70 per cent in counties having an assessed valuation greater than $5,000,000, and is decreased 10 per cent for each $5,000,000 increase in valuation until only 50 per cent of the cost is paid in counties having an assessed valuation exceeding $15,000,000.

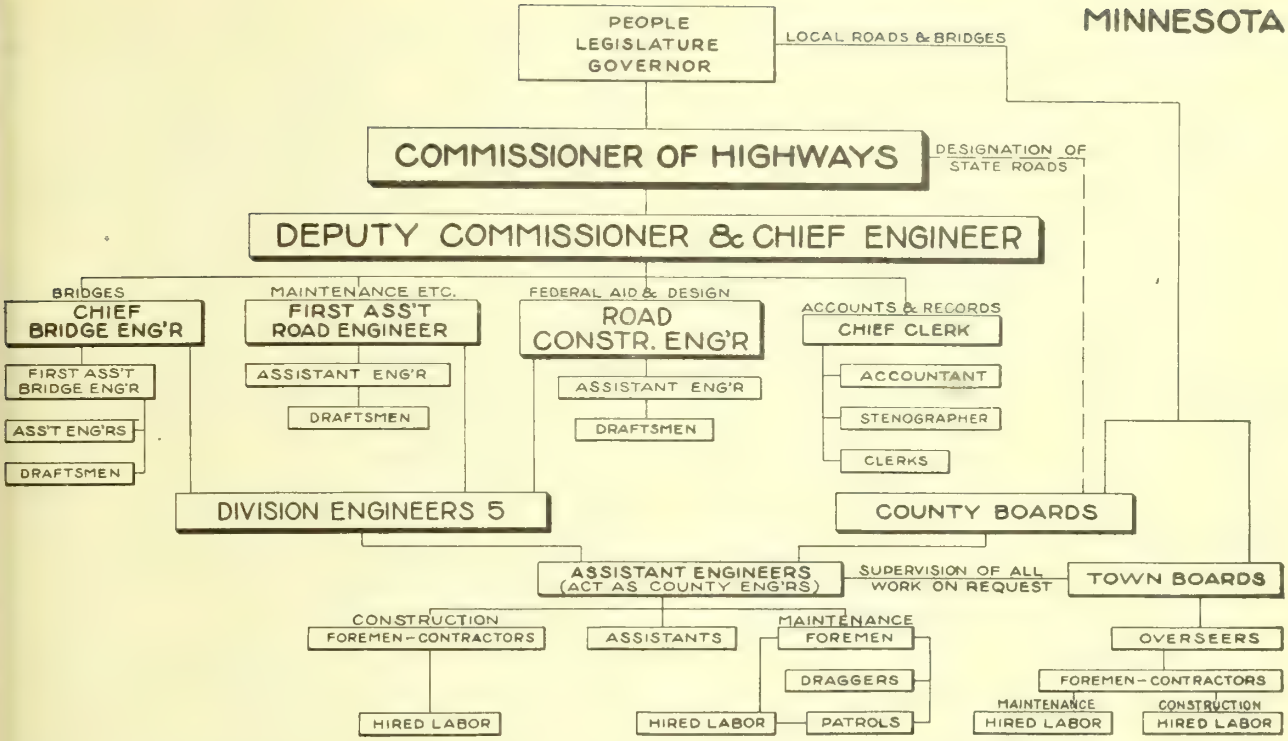
Surveys, plans, specifications, and estimates of cost for roads of this group are made on request of the county board by the assistant engineer detailed in the county. If more than $500 will be involved in the proposed improvement, the plans and specifications are required to be submitted to the State commissioner of highways for his approval. The work may be done by force account under the direction of the assistant engineer, or by contract let by the county board. If by contract, the assistant engineer is in charge of the work during its progress, and partial payment may be made by the county board when approved estimates therefor are submitted by the assistant engineer.

The final payment is not made until the work has been completed and has been viewed and accepted by a majority of the county board and until a certificate of such acceptance has been filed with the county auditor.

The county auditor then files a statement with the State commissioner of highways showing the location and cost of the work done with a report from the assistant engineer showing such details as may be required by the commissioner. When this data has been examined and approved by the commissioner, payment of the State's portion of cost is made on his order by the State treasurer.

Towns may assist counties in construction and may receive their proportionate share of the refund when granted by the State.

Roads of this class when improved are maintained by the county with State and county funds, State funds being allotted in the ratio of the division of costs of construction.



Whenever the county fails to maintain such roads, the State commissioner of highways is authorized to execute maintenance and to defray the cost thereof from the State reserve maintenance fund, and to later reimburse this fund by deductions made from future allotments to the county.

Three counties of the State operating under special laws are exempt from State supervision over road matters except in those cases where State and Federal funds are used during construction.

County roads.—These comprise all roads constructed by the county boards with county funds.

Town roads.—All other roads of the State are town roads. They are constructed and maintained by town boards with town funds.

REVENUES.

State.—The State revenues are derived from four sources, namely, (1) the proceeds of the State-wide 1-mill tax, producing about $1,550,000 annually, (2) net income from "Internal improvement fund," producing about $12,000, (3) net income from motor-vehicle licenses, producing about $50,000 annually, and miscellaneous receipts and fees, amounting to $1,500.

These revenues constitute the State highway fund, which is disbursed in the following manner: On or before January 1 of each year, the commissioner of highways estimates the total amount available for the coming year. After deducting 10 per cent of the total for the expenses of the highway department and $50,000 or less for the reserve maintenance fund, the remainder is allotted to the various counties of the State in such amounts as will provide that no county receive less than 1 per cent nor more than 3 per cent of the total allotment. Not less than 20 per cent nor more than 30 per cent of the county allotment is set aside for maintenance purposes. The maintenance is expended (1) on bridges and roads constructed in part with Federal funds and (2) on bridges and roads constructed in part with State funds.

The amounts so allotted remain in the State treasury subject to expenditure on order of the State commissioner of highways.

County.—The road and bridge fund of the county is obtained by a levy on all taxable property in the county at a rate of not to exceed 5 mills on every dollar of valuation. A special tax to meet Federal-aid funds of 5, 3, or 1 mill may be levied on each dollar of valuation dependent on whether the total valuation of the county is less than $10,000,000, greater than $10,000,000 and less than $25,000,000, or whether the valuation exceeds $25,000,000.

Towns.—The board of supervisors may levy a tax for road and bridge purposes at a rate not to exceed 15 mills on each dollar of taxable property and may if authorized by a majority vote at the annual town meeting levy an additional tax at a rate not to exceed 10 mills on each dollar of taxable property. This special tax may be paid in labor at rates prescribed by statute. A drag tax of 1 mill on each dollar of taxable property outside of the limits of incorporated cities, towns, or villages is levied. The proceeds of this tax may be expended for dragging, removing snow, or placing straw on sandy roads. The surplus in this fund on April 1 of each year may be transferred to the road and maintenance fund provided that at least $100 is left in the fund for emergency purposes.

BONDS.

Deferred serial bonds may be issued when authorized by a majority of the voters affected by counties or towns for road and bridge improvements. The counties may not incur a total bond indebtedness to exceed 15 per cent of their assessed valuation and the term of the bonds is limited to 20 years. Towns may not incur a total bonded indebtedness to exceed 5 per cent of their assessed valuation, and the term of such bonds is limited to a period not exceeding 10 years.

On January 1, 1915, $1,411,889 of bonded indebtedness incurred by counties and towns was outstanding. These bonds bore interest at 4 per cent.

MISSISSIPPI.

DEVELOPMENT.

State participation in Mississippi is limited to advisory, educational, and propaganda work by the State highway commission established in 1916. However, the approval of the State highway department is required on all plans and specifications prepared by engineers employed by county and special road district boards. Approximately $3,250,000 was expended during 1917 by the various counties for road construction and maintenance, and approximately 2,600 miles, or 5.7 of the total road mileage has been surfaced, principally with gravel and sand-clay.

ORGANIZATION.

State.—The organization of the State road department and of the counties and the relation existing between the State and local forces is shown in the accompanying chart, and is briefly described as follows:

The State highway commission is composed of three nonsalaried members appointed by the governor for a term of six years, one appointment being made every two years. The commission appoints a State highway engineer, who must be a competent civil engineer and road builder, who serves as the chief executive official of the department. His salary is $2,500 per annum and he serves four years or until removed for cause by the commission. There is also an assistant engineer appointed by the commission. The State highway department has no power to build, maintain, or supervise construction except on request of local authorities. The highway department upon request conducts campaigns of education, makes surveys, prepares plans, specifications, and estimates, and assists counties in securing competent engineers to take charge of construction work.

Local.—The county boards of supervisors have general charge of construction and maintenance of county and district roads, and the raising of revenues therefor. A county board is composed of one supervisor elected from each supervisors' district. The county treasurer acts as fiscal officer and disburses all road funds. The road taxes are collected by the sheriff, who is the county tax collector. Various provisions of law exist authorizing the building and maintaining of roads by contract and for the creation of special road districts.

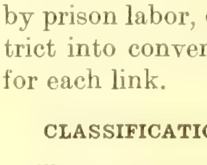
Boards of supervisors may appoint a county highway commissioner, who in turn may employ a competent highway engineer to make surveys, plans, specifications, and estimates and supervise the building of improved roads.

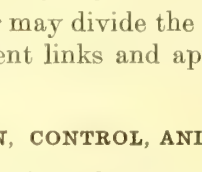
The counties may be divided by the board of supervisors into special road districts in which improved roads may be built under the direction of a district road commission composed of three members appointed by the county boards of supervisors. Such commissioners may employ a highway engineer to supervise the work.

The county supervisor of each district is required to exercise general supervision over the public roads in his district except as above indicated. The district supervisors have the work done by contract, by prison labor, or may divide the roads of their district into convenient links and appoint an overseer for each link.

CLASSIFICATION, CONTROL, AND PROCEDURE.

There are approximately 45,800 miles of public road in Mississippi, of which 2,600 miles, or 5.7 per cent, were surfaced on January 1, 1915. There are no State highways or roads to which financial aid of the State is extended. However, the State highway law provides that engineers of county boards or special districts submit to the State highway department for its approval all plans and specifications. This gives the State highway department a certain control over the construction of improved roads, and will have the effect of standardizing types, widths, gradients, and bridge structures. Local roads are usually classed as county roads, district roads, or special district roads. In those counties

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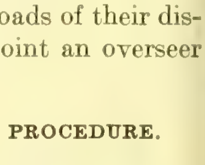

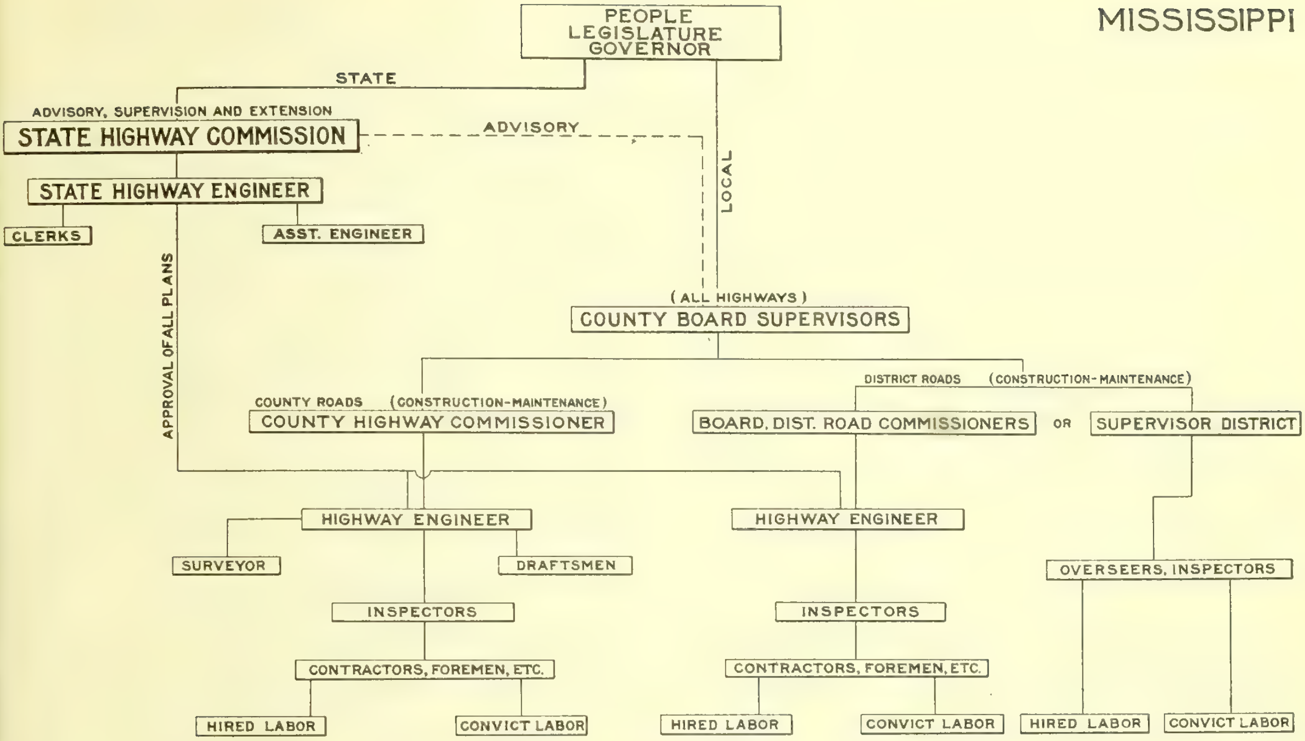

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which have county highway commissioners, or where special district commissioners are provided, the work is done by contract under the direction of an engineer, although prison labor may be employed. Statute labor tax is usually applied to district roads and under the direction of the overseers.

REVENUES.

The only State funds available are those derived from annual legislative appropriations for the support of the State highway department. This appropriation amounted to $6,500 for the year 1917.

Local roads are built and maintained from funds derived from taxation on property, statute labor tax, receipts from automobile registration fees, from funds derived from bond issues, and with jail prisoners. Supervisors are allowed to levy a money tax on all taxable property not to exceed 3 mills when the work is done by contract. An additional tax may also be levied on contiguous property for the maintenance of improved roads. Various other methods exist under the law for raising money in special districts. All able-bodied male citizens between the ages of 18 and 45 years, unless by law exempt, are required to labor eight days on the roads, or pay $3 in cash.

BONDS.

Most of the improved roads so far constructed have been built in special districts from funds derived from bond issues. The general bonding law of the State providing for the improvements of roads in one or more supervisors' districts contains a number of interesting, sound, and business-like features, namely:

1. Bonds may be issued by boards of county supervisors for a county or district on petition of 20 per cent of the qualified electors, provided the issue is not petitioned against by an equal percentage of electors, in which event an election must be held, when a majority vote decides the question.
2. The bonds outstanding must not exceed 10 per cent of the assessed valuation of property in the county or district.
3. The bonds must be paid off in annual installments between the tenth and twenty-fifth year from the date of issue.
4. A special tax must be levied annually for the payment of interest and principal, and the proceeds can be used for no other purpose.
5. A special tax of at least 1 mill must be levied for the maintenance of the road so constructed.

The total county and district bonds outstanding on January 1, 1915, amounted to $8,327,172.

MISSOURI.

DEVELOPMENT.

State assistance in laying out State roads and for the construction of bridges thereon was extended in a limited manner at irregular intervals during the period 1821 to 1860. The grant of money aid was not made a permanent policy, but was provided by special acts of the legislature for each project. From 1860 to 1907 no participation was taken in road and bridge work by State authorities. In 1907 the legislature authorized the appointment of a State highway engineer with advisory and educational duties, provided for the appointment of county highway engineers, and set aside a fund to be apportioned among the various counties of the State for road and bridge purposes. The State highway engineer was appointed by the State board of agriculture, and during the period 1907 to 1913 several bulletins dealing with road matters were published under their joint authority.

In 1913 the office of State highway engineer was abolished and a State highway commissioner was appointed by the governor. Funds were provided by the State to the extent of $15 per mile for the dragging of intercounty-seat highways. During the period 1913 to 1917 little or no supervision was provided by the State for the construction of roads of standard types. During this period, 1913–1917, considerable money was allotted by the State to the counties for construction purposes, although the State exercised little supervision other than inspection and approval of the plans proposed to be followed in the expenditure of the sums allotted. In 1917 a State highway board was authorized, a system of State highways selected for improvement under the superivion of the board, and appropriation equal in amount to Federal funds allotted was made and the State highway department was reorganized and expanded.

At the close of 1916, 7,250 miles or 7.6 per cent of the total road mileage of the State had been hard surfaced.

During 1916, $482,860 of State funds were disbursed by the State highway commissioner. This amount included allotments to counties for construction, payments for dragging of intercounty-seat roads, and the expenses of the State highway department. The total expenditure by all road and bridge forces of the State during the year totaled $7,982,860. State disbursements thus equalled 6.2 per cent of the total expenditures. During 1917 the total expenditure from all sources amounted to $7,374,933.

ORGANIZATION.

The organization of the highway forces of the State and the relation existing between them is shown on the chart given.

State.—The State Highway Department is headed by the State highway board, a bipartisan body composed of four members appointed by the governor for terms of four years, two members being appointed biennially. The board selects the State highway engineer who serves at their pleasure and is their executive official. The State highway department is required to select a State highway system, extending to each county of the State, containing not less than 3,500 miles and is required, whenever funds are available, to extend this system by the addition of at least 500 miles per annum.

The State highway engineer has supervision and control over all work done on the State highway system, is required to prepare standard plans and specifications for various types of road, bridge, and culvert construction; to furnish copies of same to all county, township, and district road officials, and to tender advice or instructions relative thereto when requested by such officials.

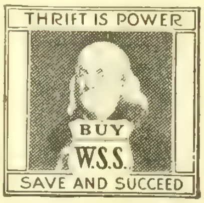
Two assistant engineers and such other employees as may be required are appointed by the State highway engineer with the approval of the board. The State highway department is required to cooperate with county courts, township and district boards, and with individuals and private associations organized for the improvement or construction, at joint expense, of roads selected by mutual agreement between the department and the individual board or body concerned.

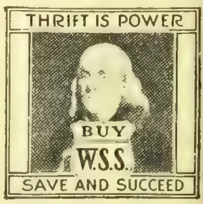
County.—In 92 counties of the State road and bridge affairs are administered by county courts composed of a presiding judge elected for a four-year term and two associates judges elected for terms of two years. The county clerk and county treasurer, elective officials, are respectively clerk and fiscal agent of the court.

The court may appoint a county highway engineer or if the office has been abolished by a majority vote of the qualified voters of the county, the county surveyor, an elective official, becomes exofficio highway engineer and assumes the duties imposed by law on the county highway engineer.

The county highway engineer is required to be skilled in road and bridge building and general road work, and has general supervision of all road and bridge work in the county. He is required to render an annual report in such manner as may be prescribed to the State highway engineer. Each county is divided by the county court into road districts, each in charge of an overseer appointed by the court who serves under the direction of the county engineer.

The county highway board composed of three members is appointed by the county court for terms of two years. This board lets contracts for dragging the intercounty seat highways. The county highway engineer is ex officio a member of the board. Monthly payments for dragging are made out of the State drag fund by the State treasurer to the various





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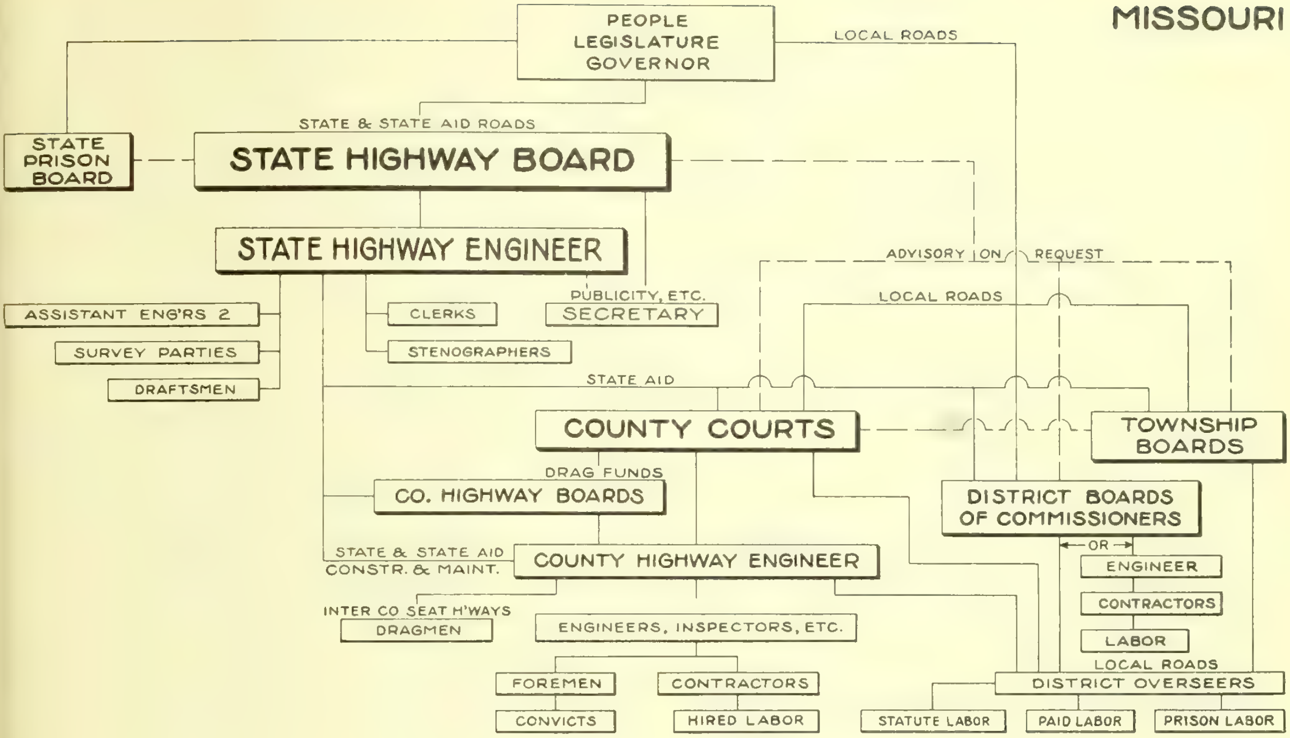


county highway boards on certificates executed by the boards and State highway engineer.

Townships.—Twenty-two counties of the State have, in addition to the regular county organization, a board of directors and other elective officials for each township in the county. The county courts of counties of this group are required to appoint a county highway engineer who has general supervision over all township road work. Road overseers in charge of the various districts of the township are appointed by the township boards. Township boards may not expend for bridge purposes more than $100 per bridge and all expenditures of $25 or over must be approved by the county highway engineer. Townships may cooperate with the State highway board for the improvement of State highways.

Districts.—The county courts of counties not under the township organization plan may authorize, when petitioned therefor, the formation of special road districts not exceeding 64 square miles in extent. The affairs of such districts are administered by a board selected by joint action of the county court and the municipal council of the town required to be included in each district so organized. Such boards may levy taxes, issue bonds, enter into contracts, etc. Counties having township organization may by order of the township boards be subdivided into special assessment districts of not less than 1 square mile in extent. Roads in such districts may be improved and the cost assessed against the land included in the district when a majority of the owners of the land affected so petition.

Improvements on State roads financed by bond issues or special taxes must be executed in accordance with plans approved by the State Highway Engineer.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 96,041 miles of public road in Missouri are divided for the purpose of fixing responsibility for construction, control, and maintenance into three general groups, namely, State roads, intercounty-seat highways, and county roads.

State roads.—These comprise a system of 7,500 miles selected by the State highway department and distributed among the various counties in proportion to their area, population, and mileage of public roads. Initiative for improvement or reconstruction is taken by the local body having jurisdiction which makes application to the State highway engineer for State aid and guarantees to pay not less than 50 per cent of the total cost of the improvement. If deemed feasible and advisable by the State highway engineer, and if State or Federal funds are available, plans, specifications, and estimates are prepared by the local body and submitted to the State highway engineer for approval.

The work may be done by day labor, by convicts detailed from the State penitentiary with the approval of the State prison board and the State highway board if request is made therefor by the county court; or the work may be done by contract let by the local body having jurisdiction. The work during progress is under the charge and supervision of the State highway engineer and on completion is inspected and accepted by him. Payments to the contractor are made by the local board and on final acceptance of the work the local body is refunded 50 per cent of the total cost by the State highway department, but if found desirable partial payments may be made by the State as the work progresses.

Federal and State aid contributed may not exceed 50 per cent of the total cost of the work. Roads of this group when completed are maintained by the county with county funds. The State highway engineer is required to inspect or cause to be inspected all roads completed under this procedure, and to compel the county to maintain them in a condition satisfactory to the State highway department.

Intercounty-seat highways.—The 11,350 miles of road connecting the county seats of the State are allotted State funds to the amount of $15 per mile per annum to be expended under the supervision of the county highway board for the purpose of dragging or otherwise improving them.

County roads comprise all other public roads of the State, They are constructed and maintained by the county, township, or district boards with local funds. They may, however, receive an allotment of State funds equal in amount to the amount provided locally for the construction of permanent improvements. The State allotment to any county for any one year for this purpose may not exceed 3 per cent of the $200,000 annual appropriation made by the State legislature for distribution to all counties of the State.

REVENUES.

State.—The State road fund is composed of revenues raised, (1) by the imposition of a motor vehicle registration fee, (2) from the sale of option stamps, (3) from fees charged for registration of corporations. Amounts raised from each of these sources of revenue are not known, but the legislature has appropriated from this fund for road improvement for the biennial period January 1, 1917, to December 31, 1918, the following amounts:

1. Support of the State highway department	$150,000
2. To meet Federal aid funds	1,020,000
3. Dragging fund	400,000
4. For permanent improvements and allotments	400,000
Total	1,970,000

1. The fund for the support of the State highway department is disbursed on order of the State highway board.

2. The fund for Federal aid is disbursed by the State highway board for projects approved and granted funds by the United States Secretary of Agriculture, the disbursements being in the ratio of $1 State funds and $1 United States funds for each $2 of local funds provided.

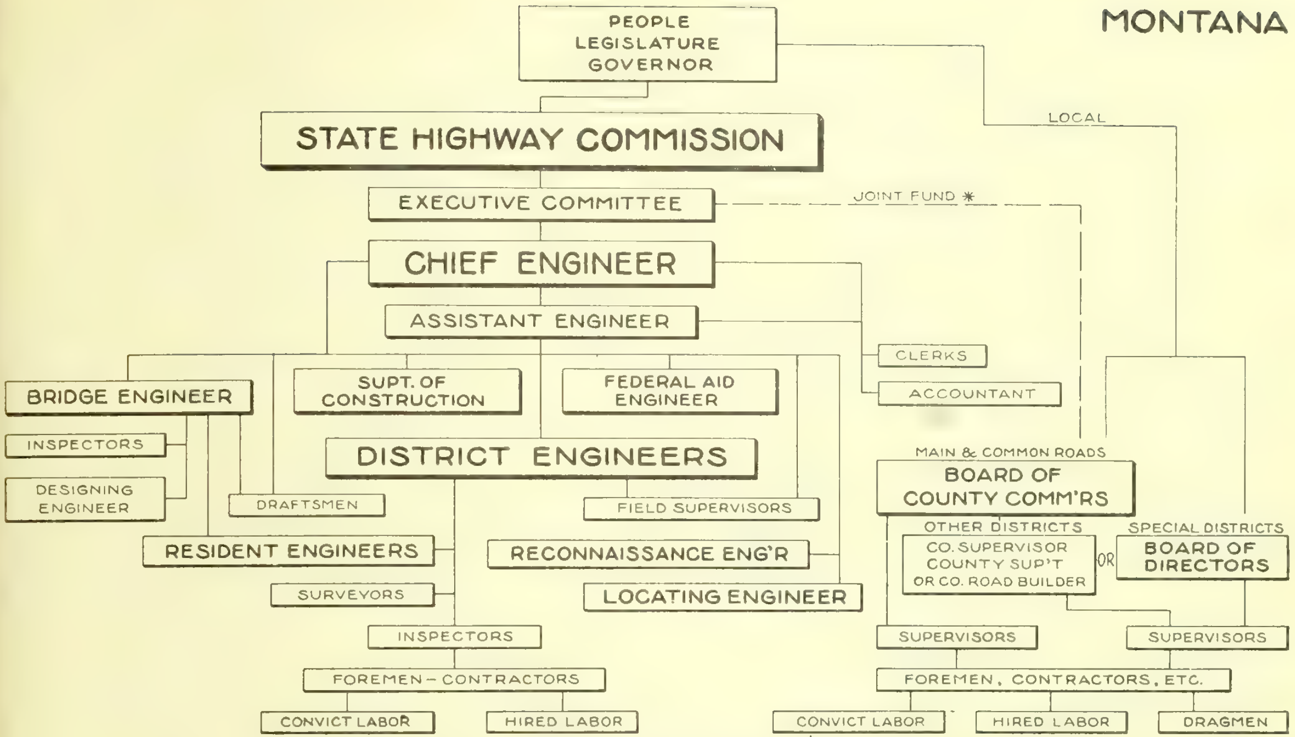
3. The drag fund is disbursed by the State highway engineer to the county highway boards to defray the expense of dragging or otherwise improving intercounty seat roads. Fifteen dollars per mile is the maximum expenditure allowed by the State.

4. The permanent improvement allotments are distributed by the State highway engineer among the several counties, townships, or districts of the State in amounts equal to the amount raised locally for specific improvements of roads or bridges, provided that the amounts so allotted be in proportion to the assessed valuation of the various counties, and no county may receive more than 3 per cent of the total fund. All improvements financed with the joint fund thus provided are required to be executed in accordance with plans and specifications approved by or acceptable to the State highway engineer.

Local.—All county courts are required to levy for road and bridge purposes a tax at a rate not less than 10 cents nor more than 20 cents on each $100 of assessed valuation of all real and personal property made taxable by law. This tax is placed to the credit of the county road and bridge fund. In counties not under township organization, a special road and bridge tax not exceeding 25 cents on $100 may be levied, and the proceeds of this tax are expended in the district in which collected. Dramshop licenses fees of $250 to $400 for each license for a six months' term are added to the special road and bridge fund. Townships may levy a road and bridge tax at a rate not less than 10 cents nor more than 20 cents on each $100 valuation. A poll tax at a rate of $4, payable in cash or labor, may be levied by the county court or township board.

BONDS.

Bonds in an amount not exceeding 10 per cent of the assessed valuation of the county and 5 per cent of the assessed valuation of the township or district may be issued by the counties, townships, or special districts for road and bridge purposes. County bonds require the approval of two-thirds of the qualified voters of the county. Such bonds are limited to 20-year terms, subject to call, however, at any time, and may bear not to exceed 5 per cent interest, payable semiannually. Township bonds, when authorized by two-thirds of the voters of the township, may be issued, to bear not to exceed 6 per cent interest, become due in 15 annual installments,



✱ STATE CO-OPERATES WITH COUNTIES IN THE EXPENDITURE OF $\frac{1}{3}$ OF THE 75% AUTO FUND APPORTIONED TO COUNTIES

the first of which shall become due not later than two years from the date of the bonds.

Special district bonds may be issued by the special boards of commissioners. Such bonds are of a type and are issued in a manner similar to that described under township bonds.

On January 1, 1915, there was outstanding a total of $522,500 of bonds issued by the counties of Missouri for road and bridge purposes. These bonds bore interest at the rates of 5 and 6 per cent, and were issued for terms varying from 10 to 15 years.

MONTANA.

DEVELOPMENT.

State participation in road improvement in Montana is of recent origin, limited in scope, and consists of a small amount of money aid derived from automobile registrations applied to a system of State highways administered by a State highway commission.

State interest in road improvement was first manifested in 1913, when there was established a State highway commission consisting of three members and a State highway fund for the improvement of a system of State roads. The commission consisted of two ex officio members and a secretary-engineer, who was virtually the State highway engineer of the department. From 1913 to 1917 State activity was limited to the use of State convicts on road work and to the furnishing of plans, specifications, and supervision of bridges.

In 1917 this commission was abolished and a new commission, consisting of 12 appointive members, was provided for. The fund at the disposal of the commission for administration and for construction and maintenance of State highways consists of 50 per cent of the net automobile registration fees, which amounted to approximately $131,500 in 1917. The local expenditures during 1916 amounted to approximately $3,500,000. The money over which the State exercises complete control, therefore, represents approximately 3.5 per cent of the total.

ORGANIZATION.

The organization of the State highway department and the relation between the State and local forces is shown in the accompanying diagram and is briefly described as follows:

State.—The State highway commission consists of 12 nonsalaried members appointed by the governor, one from each of the 12 districts into which the State is divided for this purpose. Three are appointed each year for a term of four years and no more than six members are to be of the same political party. They elect biennially from their membership three members to act as an executive com-

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mittee, one of whom is designated as president of the commission and chairman of the committee. This would appear to be a rather cumbersome organization, but it is evidently the intent of the law to have the commission handle questions of policy while the committee is to act for the commission in an executive capacity. This committee meets each month to let contracts and transact other business. It employs all engineering and clerical assistants. No State highway engineer is provided for by law, but a chief engineer at a salary of $3,600 and a bridge engineer at a salary of $3,500 and other engineers at salaries ranging from $2,400 to $3,000 per annum have been appointed by the executive committee.

The commission may have State highways constructed and maintained by its own engineers, or it may have the work done by local authorities under State supervision, and in accordance with rules and regulations issued by the commission.

Local.—The board of county commissioners is vested with general supervision over all roads except those designated as State highways and even State highways may remain under county control if the State authorities so elect. The county boards are composed of three members, one being elected biennially for a term of six years. They may employ a competent road builder to supervise all county work or they may direct the county surveyor to do this, and may divide the county into districts and appoint supervisors in charge of each.

Special districts may be established in a county and a board of directors consisting of three members may be elected for each district. The directors appoint a supervisor under whose immediate control all roads in the district are constructed or repaired. The boards of county commissioners continue to exercise the power to lay out and construct new roads in such districts and may appoint a county road superintendent with whom the district supervisors must cooperate.

Assessment districts may also be organized for the improvement of main highways. The work in such districts is handled by the county surveyor and the supervisors in whose district they are located.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Montana, comprising approximately 39,200 miles, are for the purpose of fixing responsibility for construction, control, and maintenance divided into three groups, namely, State highways, main highways, and common highways. About 800 miles or 2 per cent of the total have been surfaced.

State highways.—These are designated by the State highway commission and are improved and maintained under its direction with State, Federal, and local funds. The commission has designated 2,400 miles as constituting this system, but so far no improvements have been made under the new commission. Between 1913 and 1916 about 180 miles of earth and gravel roads were improved under the old commission, largely by the use of convicts.

The procedure as to the making of surveys, the preparation of plans, specifications, and estimates, and the supervision of construction and maintenance of State highways has not as yet been definitely worked out under the new commission. This work may be done by the State forces or by local forces under State supervision. All contracts, however, must be let by the executive committee of the State highway commission and if the work costs over $1,000 it must be by competitive bidding. There is nothing in the State highway law to indicate how the maintenance of State highways will be handled or how the cost of maintenance will be paid.

Main highways and common highways.—These constitute all roads in the State not included in the State system. Main highways are improved at the joint expense of the county and assessment districts. The district must pay not less than 35 per cent and may pay as much as 75 per cent of the cost, the county paying not to exceed 65 per cent of the cost. All land within 2½ miles of a main highway may upon petition of two-thirds of the land owners abutting on it constitute an improvement district and the cost aside from the county's share may be assessed by zones. Zone 1 embraces all land within one-half mile of the road on both sides and ends, zone 2 embraces all land 1 mile in width outside of zone 1, and zone 3 embraces all land 1 mile wide outside of zone 2. Of the district's share, 45 per cent is assessed against property in zone 1, 35 per cent to zone 2, and 20 per cent to zone 3. Surveys and estimates are made by the county surveyor and contracts are let or the work done by the supervisors in whose supervisory district the roads are located.

Common highways.—These are constructed and maintained under the general direction of the county commissioners and boards of directors in special districts. The immediate supervision of the work may be handled in several different ways, depending upon whether the roads are in regular or special districts. Ordinarily the work is handled by the road supervisor.

REVENUES.

State.—Seventy-five per cent of the net receipts from the licensing of automobiles constitutes the State highway fund, 25 per cent being returned to the counties or origin to be deposited in the general road fund of the county. Two-thirds of the State highway fund is expended by the executive committee of the State highway commission for the support of the State highway department and for the construction and repair and maintenance of State highways and to meet the Federal aid fund. All State funds and Federal funds must be expended on the system of State highways. One-third of the State highway fund is apportioned among the various counties by the commission in accordance with such rules as it may adopt, to be expended under the supervision of the State highway commission. It would seem, therefore, that if 25 per cent of the automobile money is in the first instance subtracted from the total fund and turned over to the counties and if one-third of the remainder is later turned over to the counties, it is apparent that the State has absolute jurisdiction over only 50 per cent of the automobile money. The total automobile fund for the year 1917 amounted to $263,032. If the fund was handled as above indicated, this would give the State jurisdiction over $131,516 for expenditure during 1918, exclusive of balance on hand, which amounted to about $27,000, or a total of about $160,000.

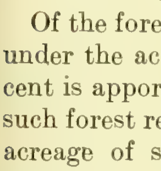
Local.—These revenues are derived from general county taxes and taxes on special and local assessment districts and from bond issues. The general county tax levied by the county commissioners must not be less than 2 mills and not more than 5 mills. There is also a $2 per capita tax on each male person between 21 and 50 years of age. These taxes apply to property and persons outside of cities in which a like tax is levied for streets.

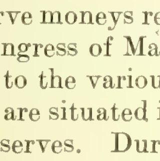
The local fund applied to roads and bridges during 1916 amounted to approximately $3,500,000.

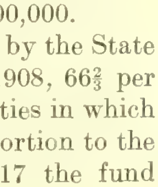
Of the forest reserve moneys received by the State under the act of Congress of May 23, 1908, 66⅔ per cent is apportioned to the various counties in which such forest reserves are situated in proportion to the acreage of such reserves. During 1917 the fund applied to roads amounted to $77,746.

BONDS.

The county commissioners may issue bonds for the improvement of State or main highways, but no indebtedness can be incurred in excess of $10,000 unless authorized by a majority vote of the electors. The indebtedness of a county is limited to 5 per cent of the assessed valuation. Bonds issued for a road improvement district must be paid in 10 years from the date of issue. The total road and bridge bonds outstanding on January 1, 1915, amounted to $2,224,000.







NEBRASKA.

DEVELOPMENT.

State participation in road building in Nebraska is limited to a small amount of State aid to roads and bridges administered by the State board of irrigation, highways, and drainage. The State contributes about 10 per cent of all road and bridge expenditures and exercises supervisory control over nearly 20 per cent of all road and bridge funds, exclusive of Federal aid.

The policy of aiding in the construction of large bridges originated in 1911 when a State-wide tax of one-fifth mill was levied for the purpose of creating a State-aid bridge fund. This tax has been levied each year since that time, and with the proceeds the State has been paying one-half of the cost of construction and maintenance of bridges over 175 feet in length.

The State-aid policy was further enlarged and strengthened in 1917 by providing a 65/100 mill State-wide levy, the proceeds from which will be used for State aid to roads, to be expended, together with Federal aid and local funds, under the direction of the State board of irrigation, highways, and drainage.

The total expenditures by all road forces of the State during the year 1917 amounted to approximately $4,603,400.

ORGANIZATION.

The highway organization of the State and the relation existing between the State and local forces is shown on the accompanying diagram.

State.—The State board of irrigation, highways, and drainage is vested with control over State aid to counties and with supervisory powers over the construction of Federal aid projects. The State board is composed of the governor, the attorney general, and the commissioner of public lands and buildings.

The State engineer, appointed for a two-year term by the board, is their secretary and chief executive official. His salary is $2,500 per annum. The State board may also appoint three persons well versed in road building, who are to act without salary in an advisory capacity and who constitute the advisory board. The State board may also appoint an engineer who shall be a civil engineer and practical road builder who shall act as secretary to the advisory board and be known as the State highway engineer. The State engineer has been appointed to this position and, therefore, occupies the quadruple position of State engineer, State highway engineer, and secretary to the State board and to the advisory board. Assistants to the State highway engineer are employed by the State board.

Local organization.—County boards are organized either under the county board of commissioners plan or under the county board of supervisors plan. Counties which have a township organization have county boards of supervisors; others have county commissioners. In both classes of counties the general control of all roads under the authority and direction of the county board is vested in a county highway commissioner appointed by the county board. Each county not under township organization is divided into from three to five districts and one commissioner is nominated from each and elected by the voters of the entire county, one being elected biennially. The county commissioners so elected constitute the county board of commissioners and has general supervision over roads and bridges in the county. They divide the county into districts, for each of which an overseer is elected. The road overseers are responsible to the county highway commissioner. Road dragging districts may be established and a superintendent of dragging may be appointed for each district.

The counties under township organization are divided into seven supervisor districts, each district electing a supervisor, the seven constituting the county board of supervisors. This board divides the county into townships. Each supervisor has charge of the expenditure of county funds apportioned out of the county treasury for his district.

Counties under township organization may vote to have township supervisors, in which event one supervisor is elected for each township and the supervisors thus elected constitute the county board of supervisors. The governing body of the township known as the township board, consists of a town clerk, an assessor, and a justice of the peace. Each year the township board selects one of its number as township highway superintendent, to have charge of all township road and bridge work.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Nebraska comprise about 80,300 miles, of which about 1,300 miles, or 1.7 per cent have been surfaced. For the purpose of fixing responsibility for construction, control, and maintenance these roads may be divided into three classes, namely, State-aid roads, county roads, and township roads.

State-aid roads.—The designated system of State-aid roads, on which State and Federal funds will be applied, together with local funds, includes about 4,000 miles. After improvement these roads will be maintained by the counties under State supervision.

The State board is authorized to furnish all bridge plans for structures costing over $500 each and to advise with county boards in regard to the building of roads and bridges, and upon request of the county boards to assist in the preparation of plans and in the supervision of work of construction and maintenance. Roads and bridges built or maintained with the aid of State or Federal aid funds must be constructed under the supervision of the State board. The State board has no authority to designate on its own initiative the roads to be constructed with State or Federal aid funds, such power being vested specifically in the county boards. Construction contracts on State-aid roads and bridges are let by the county and State acting jointly.

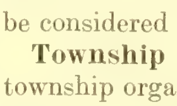
Applications for State-aid on bridges are initiated by county authorities. The State pays one-half of the cost of construction and one-half of the cost of maintenance exceeding $100 per annum on State-aid bridges 175 feet in length and over. The proportion of the cost of construction of State-aid roads to be borne by the State and the counties is not definitely fixed.

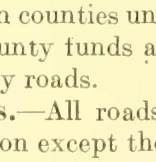
County roads.—All roads in counties not under township organization and not included in the State-aid system and to which county funds are contributed, and all roads in counties under township organization to which county funds are contributed may be considered county roads.

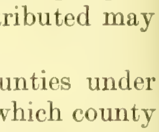
Township roads.—All roads in counties under township organization except those to which county or State funds are contributed may be considered township roads.

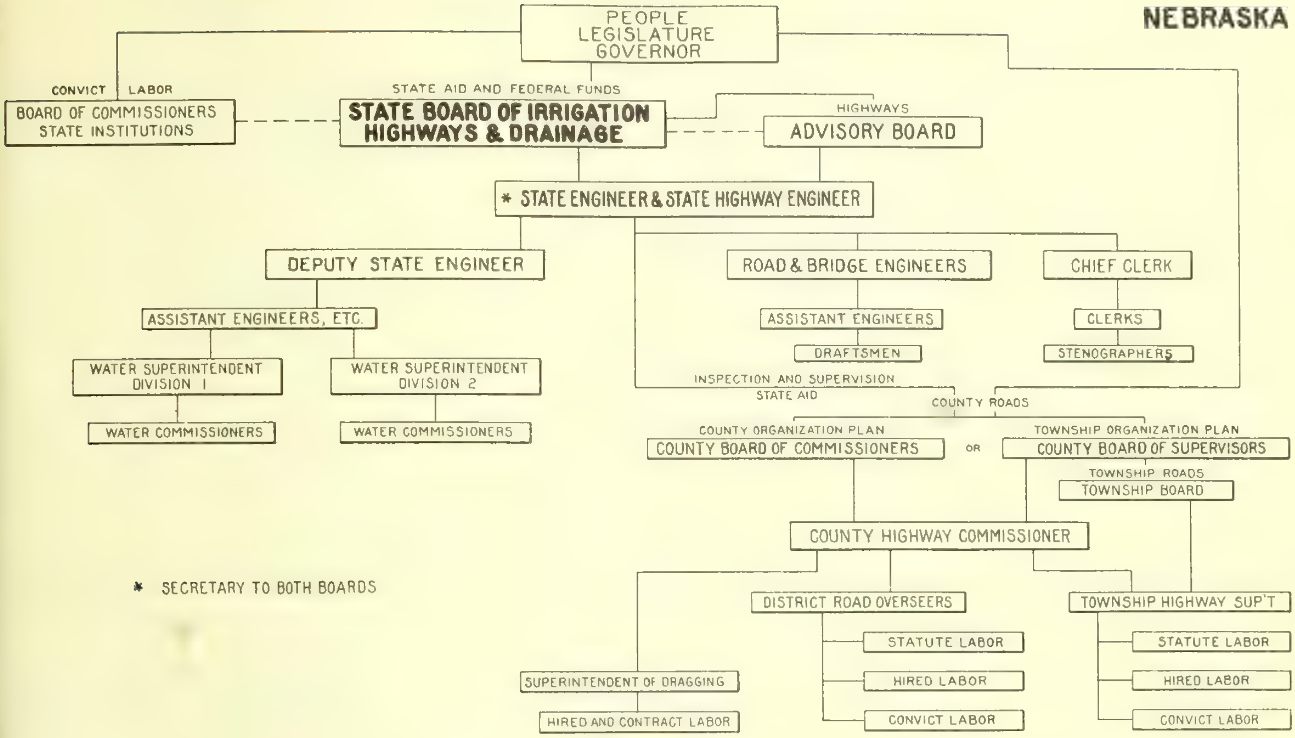
REVENUES.

State.—A State tax of one-fifth of a mill is levied annually, the proceeds from which are used to aid the counties in constructing and maintaining bridges of 175-foot span and over. A State tax of $\frac{65}{100}$ of a mill is also levied, the proceeds from which are used to aid the counties in constructing roads. Of the one-fifth mill tax which produces about $110,000, approximately $105,000 or 95 per cent of the total raised is available for expenditure. There has been appropriated by the legislature








NEBRASKA
PEOPLE
LEGISLATURE
GOVERNOR
CONVICT LABOR
BOARD OF COMMISSIONERS STATE INSTITUTIONS
STATE AID AND FEDERAL FUNDS
STATE BOARD OF IRRIGATION HIGHWAYS & DRAINAGE
HIGHWAYS
ADVISORY BOARD
* STATE ENGINEER & STATE HIGHWAY ENGINEER
DEPUTY STATE ENGINEER
ROAD & BRIDGE ENGINEERS
CHIEF CLERK
ASSISTANT ENGINEERS, ETC.
ASSISTANT ENGINEERS
CLERKS
DRAFTSMEN
STENOGRAPHERS
WATER SUPERINTENDENT DIVISION 1
WATER SUPERINTENDENT DIVISION 2
WATER COMMISSIONERS
WATER COMMISSIONERS
INSPECTION AND SUPERVISION
STATE AID
COUNTY ROADS
COUNTY ORGANIZATION PLAN
COUNTY BOARD OF COMMISSIONERS
OR
TOWNSHIP ORGANIZATION PLAN
COUNTY BOARD OF SUPERVISORS
TOWNSHIP ROADS
TOWNSHIP BOARD
COUNTY HIGHWAY COMMISSIONER
* SECRETARY TO BOTH BOARDS
DISTRICT ROAD OVERSEERS
TOWNSHIP HIGHWAY SUP'T
STATUTE LABOR
HIRED LABOR
CONVICT LABOR
STATUTE LABOR
HIRED LABOR
CONVICT LABOR
SUPERINTENDENT OF DRAGGING
HIRED AND CONTRACT LABOR

$320,000 for State aid to roads for each of the years 1917 and 1918. The $\frac{65}{100}$ mill tax is expected to raise about $327,500 a year, but any balance over $320,000 a year appropriated by the legislature will accumulate in the State treasury pending further legislative action.

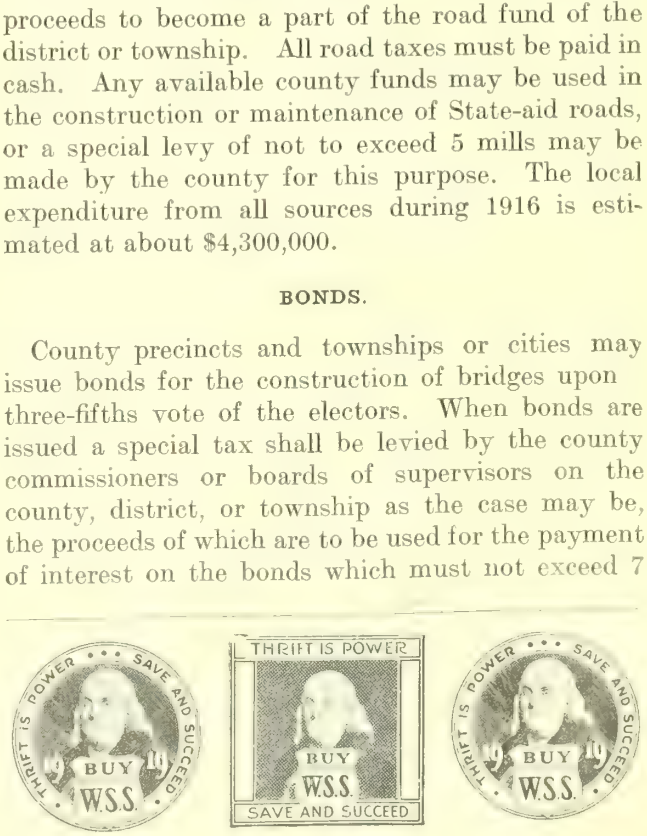
State-aid funds for State-aid roads and bridges, therefore, amount at present to about $425,000 a year. State-aid road money together with the Federal-aid road money is apportioned to the various counties on the basis of area, mileage of post roads, and population, each having a weight of one-third. Project districts each containing not over five counties have been established and all State and Federal funds in each district will be considered as a unit for such district and will be available for expenditure on a single project each year. By this arrangement it will not be necessary to build a road in each county each year, but it is planned to build a road in each county during the five-year period.

Local revenues.—Road and bridge taxes are levied by the county commissioners or the boards of supervisors. The road tax shall not exceed 5 mills and the bridge tax not to exceed 4 mills. The proceeds from inheritance taxes and net receipts from the registration and licensing of automobiles are used for road construction and maintenance. In counties not under township organization, one-half of all the money collected constitutes a county road fund, and is divided equally among the commissioner districts. The other half is apportioned to the districts for expenditure under the direction of road overseers. In counties under township organization, one-half of the road money collected from taxation constitutes the district road fund and one-half constitutes the town road fund.

On petition of a majority of resident freeholders of any road district or township, the county board may levy a tax from not less than 5 nor more than 25 mills on the taxable property of the districts, the proceeds to become a part of the road fund of the district or township. All road taxes must be paid in cash. Any available county funds may be used in the construction or maintenance of State-aid roads, or a special levy of not to exceed 5 mills may be made by the county for this purpose. The local expenditure from all sources during 1916 is estimated at about $4,300,000.

BONDS.

County precincts and townships or cities may issue bonds for the construction of bridges upon three-fifths vote of the electors. When bonds are issued a special tax shall be levied by the county commissioners or boards of supervisors on the county, district, or township as the case may be, the proceeds of which are to be used for the payment of interest on the bonds which must not exceed 7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per cent, and for the creation of a sinking fund with which to redeem the bonds at maturity. Townships and precincts may issue bonds in amounts not to exceed 10 per cent of the taxable valuation for roads and bridges when authorized by a two-thirds vote. In counties having a population of over 20,000 bonds may be issued for the improvement of special roads on petition of property owners and the money to pay the interest and principal on the bonds may be assessed against the lands lying within 2 miles of the road improved. So far as can be ascertained no county, township, or district bonds have been issued.

NEVADA.

DEVELOPMENT.

State participation in road improvement was first manifested in Nevada in 1911 by the appropriation of $20,000 to equip convict camps used under the supervision of the State engineer in the construction of trail roads. The State legislature from time to time designated certain roads as State roads, but placed the burden of construction and maintenance on the counties in which they were located.

State funds were not again made available for road improvement purposes until 1917, at which time the State highway department was organized. A system of State highways was selected and a fund was provided for its improvement under the supervision of the State highway department.

Highway improvement prior to 1917 was almost entirely under the charge of the local officials, and due to the limited travel, soil, and climatic conditions graded and drained earth roads comprised the principal type of construction. However, on January 1, 1917, 320 miles, or 2.6 per cent, of the total road mileage of the State had been surfaced, while 1,800 miles, or 14.8 per cent, had been graded and drained.

During the year 1916 local expenditures for road and bridge purposes amounted to $275,000, no State funds being available for use during this period.

During the year 1917 a total expenditure of $336,796 was made by all road forces of the State for highway purposes. Of this amount $36,796, or 10.7 per cent, was contributed by the State.

ORGANIZATION.

The organization of the road forces of the State and their relation is shown on the diagram.

State.—The department of highways is composed of the board of three highway directors appointed by the governor for terms of three years, and the State highway engineer appointed by the board. Such assistant engineers, clerks, and other assistants as may be required are employed by the State highway engineer at rates of compensation fixed by the board.

The State highway engineer as executive official of the department has full charge of all work in the State road system, general supervision over the expenditure of State funds allotted to the counties for aid in the construction of important local roads, is required to establish standards of construction best adapted to the sections of the State and to advise with and require reports from the various local officials throughout the State.

County.—The county board of commissioners, consisting of three members and in counties with more than 4,000 voters of five members, elected for terms of two and four years, with the county assessor and district attorney, comprise the board of county highway commissioners, vested with jurisdiction over the construction and repair of all county roads. This board may appoint a county road supervisor as its executive official, or on petition of the interested residents the board may appoint a board consisting of one or three road commissioners for each district created by the board. The commissioners thus appointed may subsequently be elected if desired by the residents of the district.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 12,182 miles of public road in Nevada are, for the purpose of fixing responsibility for control, construction, and maintenance, divided into two groups, viz, State highways and county roads.

The State highways.—These comprise 1,400 miles of road selected by the State legislature for improvement under the supervision of the department of highways with Federal and State funds. All surveys, plans, specifications, etc., are made by the department and approved by the United States Secretary of Agriculture, if the use of Federal funds is contemplated. Construction may be executed by convict labor under the supervision of the department, or the work may be let through contract by the department. During progress the work is under the supervision of the inspector assigned by the State highway engineer.

Monthly payments covering 85 per cent of the completed work may be authorized by the State highway engineer, the claim for which, however, must be approved by the State board of examiners.

Final payment covering all remaining balances is made in a similar manner when the completed

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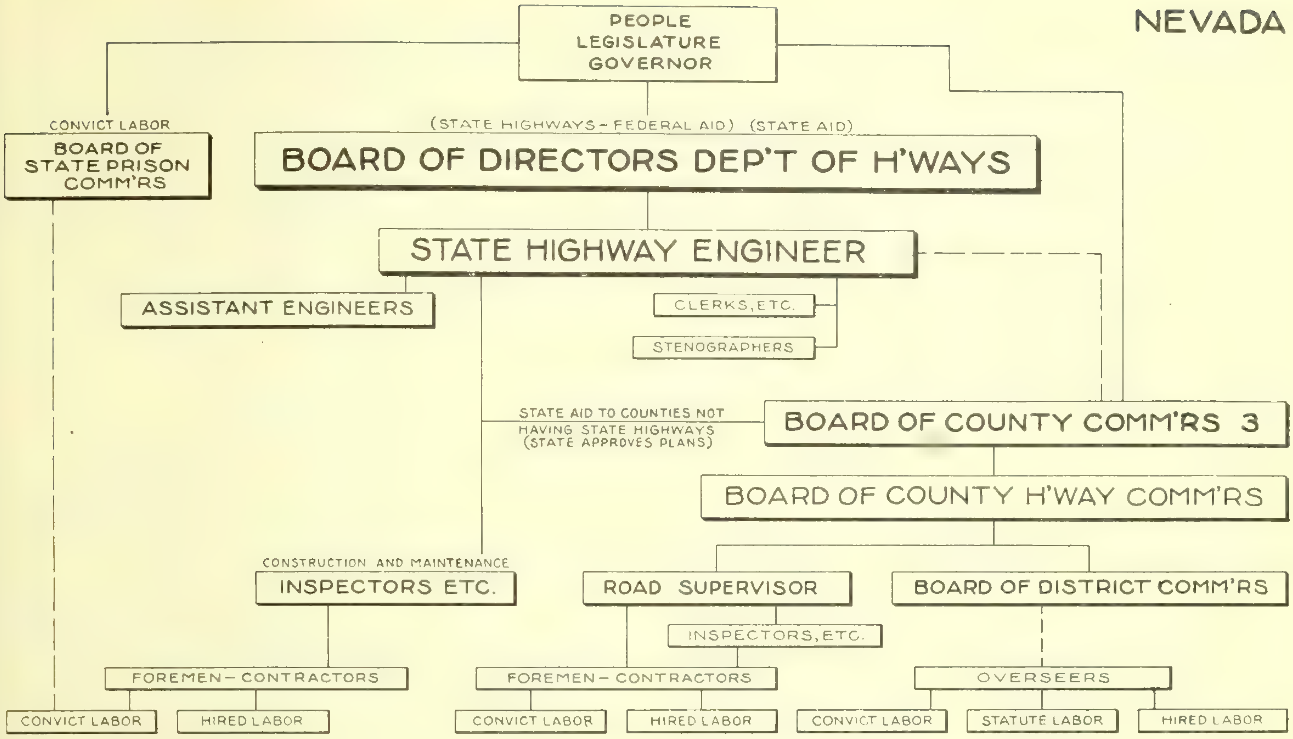

work has been accepted by the State highway engineer or his representative.

Completed roads of this group are administered and maintained by the department of highways at State expense.

County roads.—All other public roads of the State are classed as county roads and are further subdivided into main county roads and general county roads, according to the amount of travel thereon. When a road of either classification is improved, it is known as a standard county road. It is intended to improve the roads of each county in the order of the amount of travel sustained. Improvements are made under the order and direction of the county board of highway commissioners. However, when State-aid funds are utilized, the department of highways prescribes standards of construction to be followed. Plans and specifications are required for all improvements costing $500 or more, and the use of perishable materials for bridge and culvert construction, while not entirely forbidden by law, is restricted to temporary or emergency repairs.

Whenever the estimated cost of improvement is $500 or more, the county board of highway commissioners is required to advertise for bids. The bids may be rejected and the work done by day labor, or the contract may be let.

The State highway engineer may, on request of the county board, take charge of and supervise any county work.

Completed roads of this group are maintained by county officials at county expense.

REVENUES.

The State highway fund for the year 1917 was composed of an appropriation of $40,000 made by the legislature; the proceeds of the $\frac{7}{10}$-mill State-wide tax, which produced $128,509.63; the net proceeds of the motor-vehicle tax collected in counties in which sections of the State highway are located amounted to $25,000; one-sixth of the net proceeds received by the State racing commission from the sale of parimutuels, which amounted to $11,365.16; making a total of $207,728.14. Also from the automobile road fund there was the sum of $12,853.35 collected in previous years from automobile licenses.

In addition thereto about $117,331.14, which comprised the county State highway fund, was raised by a $\frac{7}{10}$-mill tax levied by the counties in which were located sections of State highways. This fund, combined with Federal or State funds, is expended by the department of highways on the State highway system and can be used for no other purpose.

The State highway fund is available for the support of the department of highways, the construction of highways and their maintenance, and for allotment of State aid to counties not having State highways in their borders. The State aid thus allotted to counties consists of the amount contributed to the State highway fund by reason of the $\frac{7}{10}$-mill State-wide tax less the proportionate share of the overhead of the department of highways, and an additional sum equal to the county's share of the Federal aid allotted to the State.

County.—The counties in which no State highways are located are entitled to a refund of the net motor-vehicle license fees paid by the residents of the county. Such fees are credited to the auto road-repair fund available for expenditure by the county board.

A general county road tax at a rate not exceeding one-fourth of 1 per cent may be levied by the county board and expended in the various districts in which collected. A special tax at a rate not exceeding 30 cents on $100 valuation may, on petition of a majority of the property owners of the district, be levied on all taxable property in the district. This tax may be paid in labor.

A poll tax at the rate of $3 is levied on all male inhabitants between the ages of 21 and 60. The proceeds of this tax are expended in the districts in which collected.

BONDS.

Counties may, when authorized by a majority vote of the electors of the county, issue serial-type bonds for a term not exceeding 40 years in amounts not exceeding 3 per cent of the assessed valuation of the county. The rate of interest is fixed by the county board, but shall not exceed 6 per cent.

There was outstanding on January 1, 1915, a total of approximately $38,000 road and bridge bonds issued by counties.

NEW HAMPSHIRE.

DEVELOPMENT.

State interest and participation in road construction and maintenance has been a permanent policy since 1903, is extended to a system of State highways, trunk-line highways, and to State-aid roads, and is administered by a State highway department.

State participation began in 1903 with the appropriation of funds for special projects. However, in 1905 steps were taken to designate and assist in the construction of a system of State roads, and since that date State assistance has been granted each year.

In addition to the construction of roads which are, in general, of State importance, provision has been made for State aid in the construction of important local roads.

On January 1, 1917, 1,900 miles, or 13.5 per cent of the total road mileage of the State, had been surfaced. Sixty-seven and five-tenths per cent, or 1,280 miles, of this improved mileage had been constructed under the State highway or State-aid plan.

During the year 1916, $414,669 of State funds and $430,742 of local funds were expended by or under the supervision of the State highway commission. The total expenditures during the year by all forces, State and local, reached $2,045,410. The State thus contributed 21.4 per cent and exercised supervision over 41.3 per cent of all expenditures.

During the year 1917 the total expenditure by all forces reached $2,240,000.

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ORGANIZATION.

The organization of the State for highway control, the State highway department, the local units, and the relation between State and local officials is shown in the chart given.

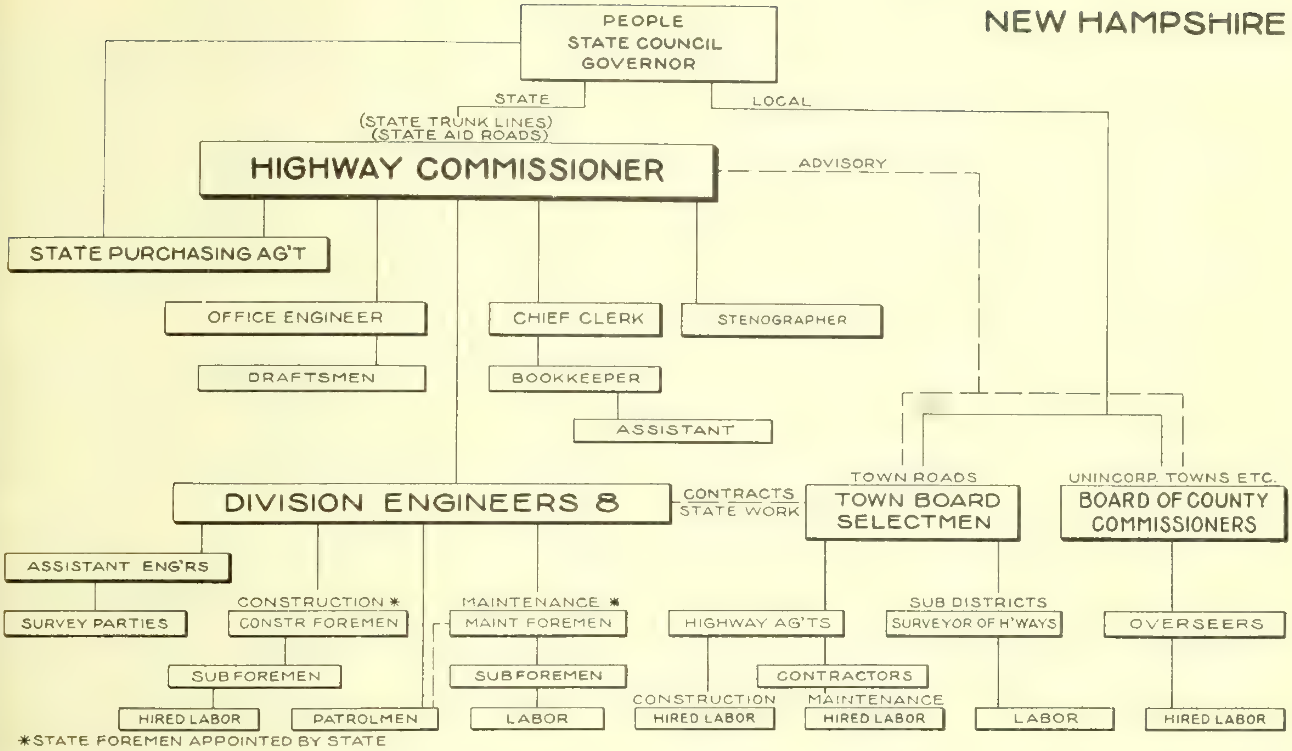
State.—In charge of State work on either the State trunk lines or State-aid roads is a State highway commissioner appointed by the governor for a term of five years. He is required to be a competent road builder and is executive head of the department and technical head of the engineering forces. The staff consists of technical and clerical help outlined in the chart. For purposes of control he has divided the State into eight divisions with a division engineer in charge of each. Each division engineer is assisted by the necessary surveyors and inspectors, and he appoints construction and maintenance foremen, with the approval of the commissioner for trunk-line and State-aid work. Most of the work is done by force account or day labor, although the work can be let on a contract basis according to law. Foremen are usually paid annual salaries to keep them available for continuous service.

Town.—Authority over road and bridge affairs in organized towns is vested in a board of selectmen elected annually at the town meeting. The board selects from one to three highway agents who supervise and execute construction and maintenance of town roads, or the town may be divided into districts each under the charge of a surveyor of highways appointed by the board. The affairs of towns not organized are administered by the county board of commissioners.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 14,020 miles of public roads in New Hampshire are divided for the purpose of fixing responsibility for control, construction, and maintenance into four groups, namely, State highways, trunk-line or cross-State highways, State-aid highways, and town roads.

State highways.—These comprise 135 miles of highway selected by the legislature to be constructed



and maintained at State expense under the direction of the State highway commissioner.

Trunk-line or cross-State highways.—These comprise about 584 miles of road selected in a general way by the State legislature, the details of location being left to the State highway commissioner. Such roads are constructed by the State highway department at State and town expense, the towns contributing in general 50 per cent of the cost, although the poorer towns may be permitted by the commissioner to contribute a lesser percentage. Roads of this group are maintained by patrolmen under the supervision of the State highway department, and are paid with local funds and State funds derived from the registration of motor vehicles. All construction work on State highways and trunk-line or cross-State highways is under the charge of the State highway commissioner. Contracts are let for work involving the expenditure of $1,000 or more, while force account labor is used on work of lesser amount.

State-aid highways.—These comprise 671 miles of important local roads selected by joint agreement between the State highway commissioner and the county or town boards. Such roads are improved by the towns under State inspection and supervision, the cost of the work being borne as follows: One-sixth to three-fourths of the total cost is paid by the State, the percentage being dependent on, and inverse to, the assessed valuation of the towns affected. State aid may not be expended on local roads until the existing mileage of trunk-line or cross-State highways in the towns concerned has been improved.

Improved roads of this group are maintained in a manner similar to that described under trunk-line and cross-State highways.

Town roads.—These comprise all other roads of the State. They are constructed and maintained by town forces at town expense.

REVENUES.

State funds.—The State funds for highway improvement are provided by legislative appropriation and for the year ending August 31, 1918, the following amounts are available:

1. For the support of the State highway department, maintenance of State highways, maintenance of trunk-line and cross-State and State-aid highways, $450,000. Of this amount $350,000 will be collected from motor-vehicle licenses and will be disbursed as follows: Thirty-five per cent to the State-aid roads, 65 per cent to trunk-line and cross-State highways.

2. For construction of trunk-line and cross-State highways and to meet Federal-aid funds, $200,000.

State funds for State-aid purposes, either trunk-line or cross-State highways, and State-aid highways are apportioned among the towns as follows:

1. To towns of $100,000 or less assessed valuation, $3 for each dollar appropriated by the town.

2. To towns of more than $100,000 and less than $250,000 assessed valuation, $1.25 for each dollar appropriated.

3. To towns of more than $250,000 and less than $1,000,000 assessed valuation, $0.60 for each dollar appropriated.

4. To towns of more than $1,000,000 and less than $3,000,000 of assessed valuation, $0.25 for each dollar appropriated.

5. To towns of more than $3,000,000 assessed valuation, $0.20 for each dollar appropriated.

The towns are required to contribute to this fund in the following ratios:

1. Towns with an assessed valuation of less than $2,000,000, $1 for each $1,000 of valuation.

2. To towns of more than $2,000,000 and less than $3,000,000 assessed valuation, $0.75 for each $1,000.

3. Towns of more than $3,000,000 and less than $5,000,000 assessed valuation, $0.50 for each $1,000.

4. Towns of more than $5,000,000 and less than $15,000,000 valuation, $0.33⅓ for each $1,000.

5. Towns of more than $15,000,000 valuation, $0.25 for each $1,000.

Town.—In addition to the contribution to the State-aid fund town funds are raised by a tax levied by the town board. This tax may not be less than one-fourth of 1 per cent of the assessed valuation and may not produce a fund in excess of $50 per mile of road in the town.

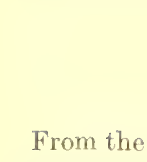
BONDS.

On September 1, 1914, there was outstanding a total of $675,000 of State highway bonds. These are of the deferred serial type, fall due between 1915 and 1924, and bear interest at 3 and 3½ per cent.

NEW JERSEY.

DEVELOPMENT.

From the standpoint of State participation in road work New Jersey was the pioneer in point of time. It deserves the distinction of being the first State to adopt the principle of State aid, but it was not until 1917 that a State highway system was established. At present the State has absolute control over approximately 4.5 per cent and supervisory control over the maintenance of 21 per cent of the total road mileage of the State. The first actual appropriation for State aid was made in 1892, and amounted to $75,000, but during the fiscal year, November 1, 1917, to October 31, 1918, the State funds available for construction and maintenance of State and State-aid roads amounted to over $5,500,000.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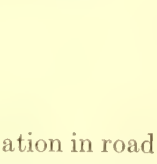
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When the State-aid plan was first adopted the initiative for State-aid work was vested with local authorities. Contracts were let by local authorities while the general inspection and supervision was vested in State authorities. In general this plan still obtains so far as State-aid work is concerned. At present about 2,100 miles have been constructed through the aid of the State. The contributions from State funds have amounted to about $9,500,000. The first State-aid law provided that abutting property owners pay 10 per cent of the cost, the State one-third and the county the balance. In 1902 the law was so changed as to provide that no part of the cost was to be assessed against the abutting property except in the form of regular taxation.

The urgent need for a connected system of State highways over which the State could exercise absolute control was met by the establishment in 1917 of a State highway system to be improved and maintained entirely at State expense. During 1916 the highway department expended $1,167,843 of State funds for construction, maintenance, administration, and engineering on State-aid roads, while $2,616,511 was expended by local authorities for the same purpose. In addition to this the local authorities expended about $2,000,000 for local road purposes.

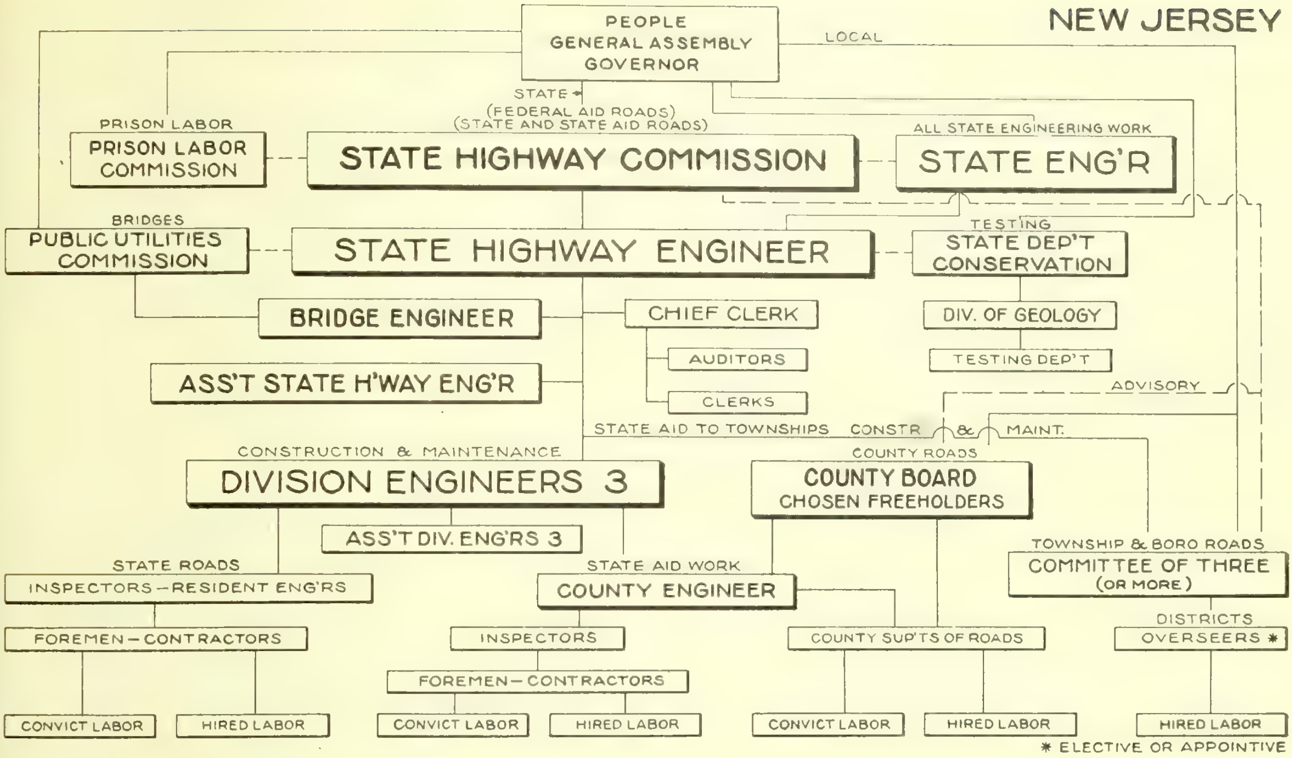
During 1917 the total expenditures by all forces reached $6,280,000.

ORGANIZATION.

The organization of the highway forces of the State and the relation existing between them is shown on the diagram herewith.

State.—The State highway department is controlled by a board known as the State highway commission. It is composed of the governor, ex officio member, and eight members appointed by the governor. Two of the commissioners must be civil engineers and all serve without salary. It is a continuous body, two members being appointed each year for terms of four years. The State engineer, appointed by the governor and whose salary is fixed by the State house commission, acts in an advisory and supervisory capacity to the highway department.

The chief executive officer of the department is the State highway engineer, who must be a qualified and competent engineer, skilled and experienced in road construction and maintenance. He is elected by the commission for a term of five years, and his compensation is fixed by the commission. The commission also elects and fixes the compensation of an assistant State highway engineer, whose qualifications and term of office are the same as the State highway engineer. The commission or the State highway engineer, or the assistant State highway



engineer, subject to the approval of the commission, appoints and fixes the compensation of such other assistants and employees as may be necessary. Such assistants and employees are appointed and hold office in accordance with civil service procedure.

Under the State highway engineer there are three division engineers. Resident engineers and inspectors handle the State road work, while county engineers handle the State-aid work. These officials report to the State highway engineer through the division engineers.

The commission has full control and direction of construction and maintenance of State highways and the elimination of grade crossings thereon. It may acquire rights of way by condemnation, purchase, or donation. It may acquire toll roads or bridges. It provides standards to which all State-aid roads must conform. It has general supervisory powers over State-aid construction and maintenance. All State and State-aid bridge work is under the general supervision of the bridge engineer of the public utilities commission, who, in addition to his duties with this commission is the head of the bridge division of the State highway department.

Local.—The boards of chosen freeholders have charge of the construction and maintenance of county roads and cooperate with the State highways department in the construction and maintenance of State-aid roads. The members are elected by the people for terms of three years and draw a per-diem allowance for the time actually employed. This body is responsible for the levying of road taxes and for the payment of accounts incurred in the construction and maintenance of county roads and the counties share of State-aid roads. County engineers may be appointed by the boards of chosen freeholders usually for terms of 5 years. County engineers have charge of engineering, construction, and maintenance of county roads and cooperate with the division engineers of the State highway department in the construction and maintenance of State-aid roads in their respective counties. When engaged on State-aid work the salary of the county engineer is paid by the county and State jointly. The county supervisors of roads, appointed by the county board of chosen freeholders, have immediate charge under the county engineer of maintenance of county roads in their respective counties. The township's road work is carried on by an elective committee of three or more members and an overseer who is elected by the people, or appointed by the township committee for each district in each township.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of New Jersey, comprising about 14,800 miles, are for the purpose of fixing responsibility for construction, control, and maintenance, divided into four groups; namely, State highways, State-aid roads, county roads, and township roads.

State highways.—A system of State highways, embracing 15 routes and including 660 miles, was designated by an act of the legislature approved March 13, 1917. These roads are to be laid out by the State highway commission, and are to be constructed by contract or with prison labor of granite, asphalt or wood blocks, asphalt or other durable material. The State will have absolute control of construction and maintenance and will pay the entire cost of construction from the 1 mill State-road tax. The maintenance costs will be paid from the automobile fees fund and from such other State funds as may be available. The State may take over any public road on the State highway system and pay the entire cost of maintenance.

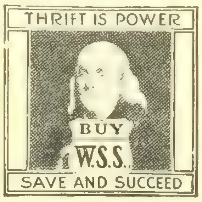
State-aid roads.—These are roads constructed and maintained with joint funds provided by the State, counties, and townships. Petitions for State-aid originate with the county boards of chosen freeholders or with township committees. Petitions are passed upon by the State highway commission. Surveys are made by county engineers with State approval and at the joint expense of the State and counties. If petitions originate with townships, the surveys are made and paid for by the State. The final approval of plans, specifications, and estimates rests with the State highway commission. The contracts are awarded by the boards of chosen freeholders or township committees on approval of the State highway commission, or the work may be done by day labor. Immediate supervision of construction and maintenance rests with the county or township subject to general inspection and supervision by the State highway department.

Payments up to 80 per cent of work done are made by the State and counties on engineer estimates as the work progresses. When final payment is made, 5 per cent of the total estimate is withheld for one year from date of acceptance as a guarantee. The State pays 40 per cent of the cost of construction, but townships may contribute 10 per cent, in which event the county pays 50 per cent. If the petition for State-aid originates with the township, the State may pay 50 per cent of the cost and the township 50 per cent. The State pays 20 per cent of the cost of bridges, when constructed in conjunction with State-aid roads.

State-aid roads are maintained by the counties or the townships at joint expense, usually 50 per cent by the State and 50 per cent by the county or the township. The State may compel proper maintenance by withholding future allotment of State aid. Up to January 1, 1917, a total of 2,112 miles of State-aid road had been constructed, while 2,487 miles were classed under the State-aid system for the purpose of maintenance.

County roads.—These are constructed and maintained entirely at county expense. There are about 2,400 miles of county roads in the 21 counties of the State.

Township roads.—These roads are constructed and maintained by the townships and include all other roads in the State not included in the above groups, except roads in boroughs, villages, cities, and towns. There are also about 12 miles of toll roads in the State.



STATE REVENUES.

In March, 1917, the legislature provided a five-year State-road tax of 1 mill, the proceeds from which are to be used at the discretion of the State highway commission for the construction of State highways.

An annual appropriation is made for State aid and for the administration of the highway department, out of which the State pays 40 per cent of the cost of State-aid roads, the counties or townships paying the balance. This money is apportioned at the discretion of the State highway commission.

The net receipts from automobile fees fund are used principally for the maintenance of State-aid roads, the State ordinarily paying 50 per cent of the cost. These funds are apportioned at the discretion of the State highway commission, usually on the basis of mileage, traffic, population, and assessed valuation. Annually there is set aside $105,000 from the automobile money, $5,000 for each county for State aid in construction and maintenance of selected township roads.

In 1917 the legislature made an appropriation for the maintenance of State prisoners used on State highways.

The State revenues available for the fiscal year November 1, 1917, to October 31, 1918, are estimated as follows:

State tax for construction of State highways	$3,000,000
Appropriation for administration and State aid	500,000
Automobile fees funds for maintenance and State aid to townships	2,000,000
Appropriation for maintenance of State prison labor	75,000
Total	5,575,000

LOCAL REVENUES.

It is impossible to say how much will be expended during the current fiscal year by counties or townships, but as the expenditures were approximately $4,600,000 during 1916, including $2,600,000 contributed to meet State aid, it is safe to say that the expenditures during 1918 will at least equal that amount.

BONDS.

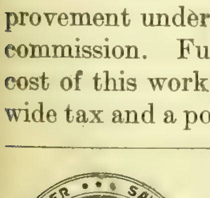
No State bonds have been issued for road improvement. Counties and townships are authorized to issue bonds for road and bridge construction. The limit of the indebtedness is 2 per cent of the assessed valuation for counties and 7 per cent for townships. For township bonds a referendum vote is provided for in case taxpayers representing 10 per cent of the assessed value of the property in the townships sign a petition for them. County boards of chosen freeholders may issue bonds without a referendum vote. The terms of all bonds are limited to the probable life of the improvement for which the bonds are issued as follows: For stone, concrete, and iron bridges, 30 years; for roads built of concrete 6 inches thick or of blocks of any material, or sheet asphalt laid on concrete foundation, 20 years; for bituminous concrete construction, 15 years; for water-bound macadam surfaced with bitumen, 10 years; and for gravel, 5 years. The law also provides that all bonds be paid off by the deferred serial method, the first payment commencing not more than two years from the date of issue. County and township bonds outstanding November 30, 1914, amounted to $14,011,000.

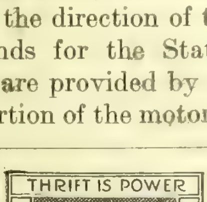
NEW MEXICO.

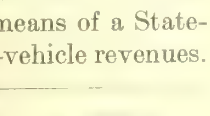
DEVELOPMENT.

State aid to road construction in New Mexico is extended by the terms of new legislation enacted in 1917 to a system of State roads to be constructed with Federal or State funds combined with local funds, and is administered by a State highway commission. State aid in New Mexico antedates statehood, as for a period of several years the Territorial legislature provided funds at irregular intervals for aid to various local road projects. In 1909 a Territorial highway commission was authorized, and additional legislation affecting the powers and duties of this body was enacted in 1912, in 1915, and again in 1917.

A system of State roads comprising a total mileage of 6,250, or 52.5 per cent, of the total mileage of public roads in the State, has been selected for improvement under the direction of the State highway commission. Funds for the State's share of the cost of this work are provided by means of a Statewide tax and a portion of the motor-vehicle revenues.







On January 1, 1917, 550 miles, or 4.6 per cent, of the total road mileage of the State were reported as surfaced, and a total of 846 miles, or 7.1 per cent, was reported as improved, the improvements having been carried out mainly under State supervision.

The total expenditures during the year 1916 for road and bridge purposes reached $828,952. Of this amount, $385,685 of State funds and $43,267 of local funds were expended by or under the supervision of the State highway commission. Thus the State contributed 46.5 per cent and supervised the expenditure of 52 per cent of the total.

During the year 1917 a total of $846,000 was expended by all forces.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown by the diagram.

State.—The State highway commission, a bipartisan continuous body composed of three members appointed by the governor for terms of six years, is at the head of the highway improvement work of the State. The State highway engineer appointed by the commission is the administrative and executive official in charge of all work instituted under the direction of the commission. He is required to advise with county officials relative to local improvements and to require reports and statistics from such officials. The State engineer has been appointed State highway engineer and receives in addition to his regular salary as State engineer $1,000 per year as additional compensation. The State highway engineer, subject to the approval of the State highway commission, is required to select the roads upon which State and Federal funds may be expended, and in cooperation with the county boards he may let contracts for such improvements. The State highway commission is required to appoint a county highway superintendent for each county in the State, or, in the discretion of the commission, a superintendent may be appointed for two or more counties. The State highway engineer with the approval of the commission appoints such assistants, clerks, etc., as may be required.

The State highway commission and the State highway engineer have, in general, the power to select the location of and to initiate improvements and to supervise the maintenance thereof when completed.

County.—Road and bridge affairs are administered by county boards of commissioners consisting of three members elected for terms of two years each. The county clerk and county treasurer are, respectively, clerk and fiscal agent of the board. The county highway superintendent selected by the

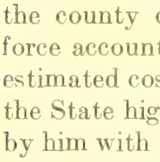
State highway commission serves as the executive official of the board in all road and bridge construction and maintenance instituted under its direction. Such foremen, assistants, etc., as may be required are employed by the superintendent with the approval of the county board. Thus the road forces of the county are under the complete control of the county superintendent of highways, who in turn is responsible to the State highway commission. All purchases involving amounts of $50 or more made by the county superintendent for supplies or materials require prior authorization therefor by the county board.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 11,873 miles of public road in New Mexico are divided for the purpose of fixing responsibility for control, construction, and maintenance into two general groups, namely, State roads and county roads.

State roads.—These comprise about 6,250 miles of road selected by the State legislature for improvement under the direction of the State highway commission. This system may be modified or extended at the discretion of the commission.

Improvement of sections of this system may be initiated by the State highway commission or by the county board. Surveys are executed, plans and specifications are prepared by the State highway engineer, and submitted to the State highway commission for approval. If the estimated cost of the work is less than $1,000, the work may be done by the county or by the State highway engineer by force account or by convict or prison labor. If the estimated cost exceeds $1,000, bids are requested by the State highway engineer and contract may be let by him with the approval of the State highway commission, and the county board concerned, or the bids may be rejected and the work completed by force account or convict labor. All work on roads of this group is executed under the supervision and inspection of the State highway engineer. Monthly payments covering 85 per cent of the completed work as evidenced by the engineer in charge of the work may be made on order of the State highway engineer. Final payment is made when the completed work has been accepted by the State highway engineer. The cost of the work may be paid from Federal and State funds, or from Federal or State funds and local funds. The local contribution in no case may exceed 50 per cent of the total cost of the work, and the State highway commission has no authority to compel any county to participate in such construction.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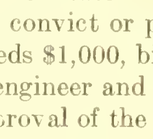

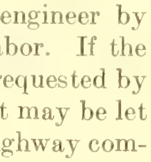
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Maintenance of the completed roads of this group is executed by the State highway commission at State and county expense, the cost being shared equally.

County roads.—All other public roads of the State are classed as county roads and are improved and maintained at county expense by the county board. However, county boards may enter into agreement with the United States Secretary of Agriculture for the improvement of roads and trails within or near the boundaries of Federal Forest Reserves.

REVENUES.

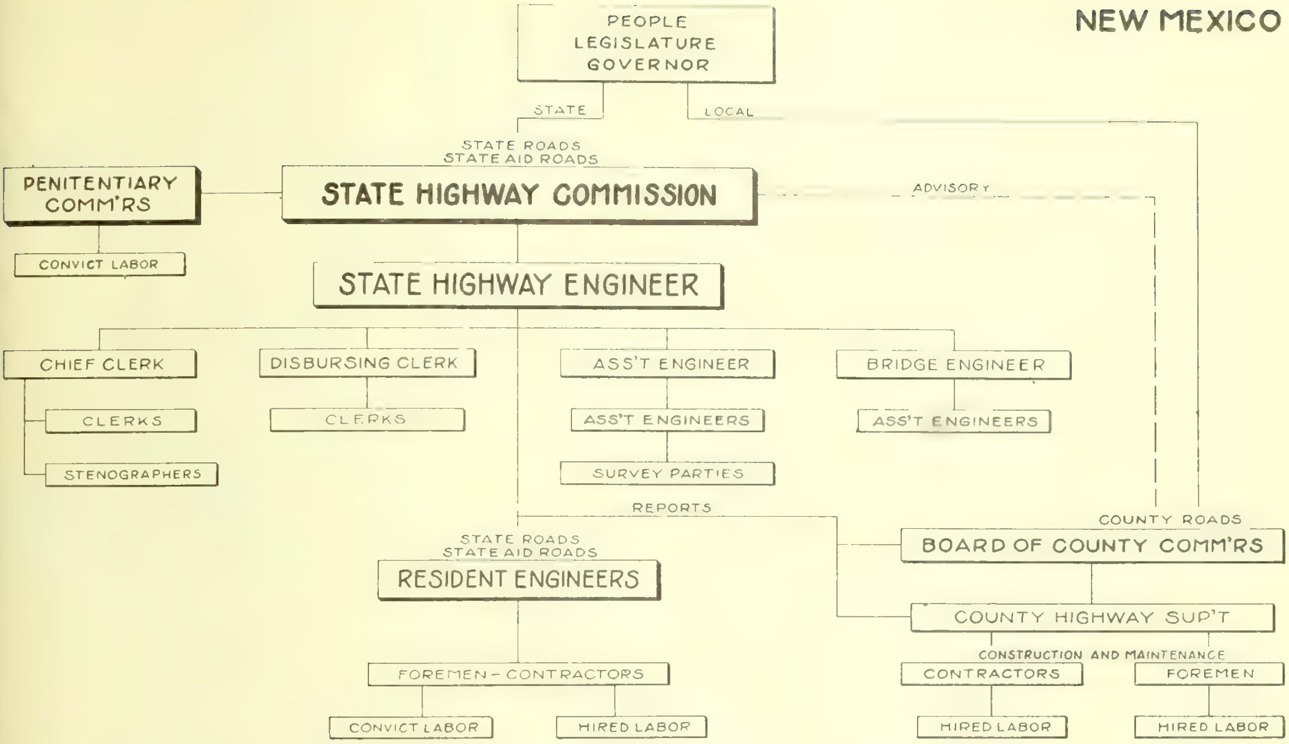
State.—State-road fund is composed of the proceeds of the State-wide one-mill tax estimated at $280,720 for 1917, and one-half of the net revenues of the motor vehicle license fund estimated at $54,970, or a total for the year of $335,690.

From this fund an amount sufficient to provide for the needs of the State highway department is deducted. From the remainder a further deduction of not less than 20 per cent of the original fund is set aside for maintenance of State roads. The amount then remaining suffers a further deduction of an amount equal to the Federal aid fund allotted the State. A further deduction is set aside to pay the interest and principal of any certificates of indebtedness issued in anticipation of the collection of the State-road fund and 75 per cent of the remainder is allotted to the various counties of the State in proportion to the assessed valuation of the property therein exclusive of the property within the limits of towns containing 2,000 or more inhabitants, as shown by the latest Federal census. Funds thus allotted and not applied for by the counties become available the succeeding year for reallotment. Money thus allotted to the county must be met by an equal amount of local funds, the combined sum to be expended on the State roads of the county.

County.—The boards of county commissioners may levy for State-aid purposes a tax at a rate not exceeding 2 mills on each dollar of assessed valuation. They may levy for bridge purposes a tax at the rate of 1 mill and for general county purposes a tax at a rate not exceeding 3 mills. Several counties of the State have been directed by the legislature to levy special taxes in order to raise funds for the construction of State roads lying within their boundaries.

BONDS.

State bonds in the amount of $500,000 have been issued for highway and bridge purposes. These bonds bear interest at 4 per cent, are of the deferred



NEW MEXICO

serial type, and must be redeemed by July 1, 1942. Payment of the principal of this issue began on January 1, 1919.

Counties may, when authorized by a majority of the voters thereof, issue sinking-fund bonds in such amount which when combined with other outstanding indebtedness will not exceed 4 per cent of the assessed valuation of the county. The interest rate may not exceed 5 per cent and the term of the bonds may not exceed 30 years.

On January 1, 1915, there was outstanding $157,000 of county bonds.

NEW YORK.

DEVELOPMENT.

New York was the fifth State to adopt the principle of State participation, the original State-aid law having been adopted in 1898. The first State appropriation amounted to only $50,000, and the control exercised by the State was relatively meager. Since 1898 the control of the State has been gradually extended. The State organization has been strengthened and enlarged and the State appropriations increased to such an extent that New York now has a powerful centralized State highway department exercising complete control over the construction and maintenance of a State system of highways embracing about 18 per cent of the total road mileage and supervisory control over all other public highways in the State.

Prior to 1898 all roads were built and maintained by the rural tax payers, about 20 per cent of the total population, representing less than 10 per cent of the assessed valuation of the State. At present the whole population and wealth of the State is drawn upon to build and care for the highways.

The Higbie-Armstrong law, passed in 1898, provided that the cost of roads selected by the county and approved by the State should be paid as follows—50 per cent by the State, 35 per cent by the county, and 15 per cent by the abutting property owners, or by the town. The State appropriation for the first year, as above indicated, was $50,000. From this small beginning has grown the present State and county system of highways for which the State appropriated upward of $10,000,000 for construction and nearly half a million dollars for maintenance during the year 1916.

In 1898 there was also adopted what is known as the Fuller-Plank Act, or the money tax law, by which the State agreed to pay one-fourth of the cost of maintaining town roads in towns maintaining a cash system of taxation instead of the previous labor tax system. In 1899 the first State aid distributed to towns under this law amounted to $34,518. This plan of aiding the towns has been gradually broadened and now embraces a certain amount of State supervision and control over all local expenditures, and a graduated system of State aid to towns whereby the State extends a greater amount of aid to the poorer towns than to the richer ones. As a result, practically all town road taxes are now paid in cash and the State fund required to meet the town funds amounts to upwards of $2,000,000 a year.

The New York State highway department has suffered many vicissitudes during its 20 years of existence. These changes have for the most part resulted from political changes in the State administration. The first attempt at systematic care of highways under State supervision occurred when the State engineer and surveyor was placed in charge of the expenditure of all State highway moneys. He continued to direct the work until 1909, when a bipartisan State highway commission was established consisting of three commissioners appointed by the governor. The law of 1909 also provided for the appointment of six division engineers.

In 1911, the organization was again changed by providing for a commission consisting of a State superintendent of highways and two ex officio members, namely, the State engineer and the superintendent of public works. This commission was to serve during the pleasure of the governor and the organization was strengthened by providing for the appointment of two deputies, one to have charge of construction and maintenance of State and county highways, and one to have charge of State aid to towns and bridge work on the highways.

The department was again reorganized in 1913, and the work was placed under the direction of a single commissioner known as the commissioner of highways. The organization has not been materially changed since that date and is described as it exists at present in the chapter on organization.

During 1916, there was expended in New York for roads and bridges $20,901,490, of which $11,400,230 was appropriated by the State. Thus the State paid during that year approximately 54 per cent of the cost of road construction and maintenance of all roads in the State.

ORGANIZATION.

The accompanying diagram shows the organization of the highway department.

State.—At the head of the highway department is a single commissioner assisted by three deputy commissioners, a secretary, and an auditor.

The commissioner is appointed by the governor with the advice and consent of the senate for a term of five years. His salary is $10,000 per annum. He has administrative control over all road and bridge work in the State, constructed and maintained wholly or in part with State funds. He prescribes the rules and regulations fixing the duties of the division engineers, resident engineers, district, county, and town superintendents, and compels all highway officials to comply with the same and carry them into effect. He is virtually, therefore, in control of all highway activities of the State. He selects and appoints the deputy commissioners, the secretary, the auditor, and division engineers. All subordinate officials and employees are selected from the register of eligibles of the civil service commission. The commissioner fixes the percentage which shall be credited by the civil service commission for experience and he fixes the salaries of all officials and employees whose salaries are not fixed by statute. The commissioner works through the heads of bureaus and the division engineers who are immediately responsible to him for results.

The first deputy shares with the commissioner the executive duties of the department, but is essentially the chief engineer in charge of construction of State and county highways. He receives a salary of $6,000 a year and is required by law to be a civil engineer experienced in road building. In the central office under the first deputy there is a resident engineer who assists on general supervision, a supervising engineer who acts as general inspector of construction work, and a supervisor of construction on special work, a bridge engineer and assistants in charge of bridge designs, a chief draftsman, and assistants, field engineers and claim agents. The division of tests which has charge of the physical and chemical testing work of the department is also under the first deputy.

The State is divided into nine divisions, each in charge of a division engineer, who has direct supervision over county assistant engineers relative to construction and maintenance of State and county highways. There are 59 county assistant engineers who report to the division engineers in their respective districts. The county assistants are responsible for both construction and maintenance in their counties, but they are assisted by engineers who are responsible for construction and maintenance, respectively. In addition to the county assistant engineers there are assigned to the division engineers one or more resident engineers who act as assistants to the division engineers, and they may be assigned to special pieces of work.

The division engineers report to the State highway commissioner through the first deputy on construction matters and through the second deputy on maintenance matters. The division engineers have charge of making all surveys, plans, specifications, and estimates in their respective divisions and certify to monthly and final estimates.

Each division engineer is provided with suitable office rooms and the necessary organization properly to carry on the work. Subdivisions of divisional offices are usually about as follows: Surveys, clerical,

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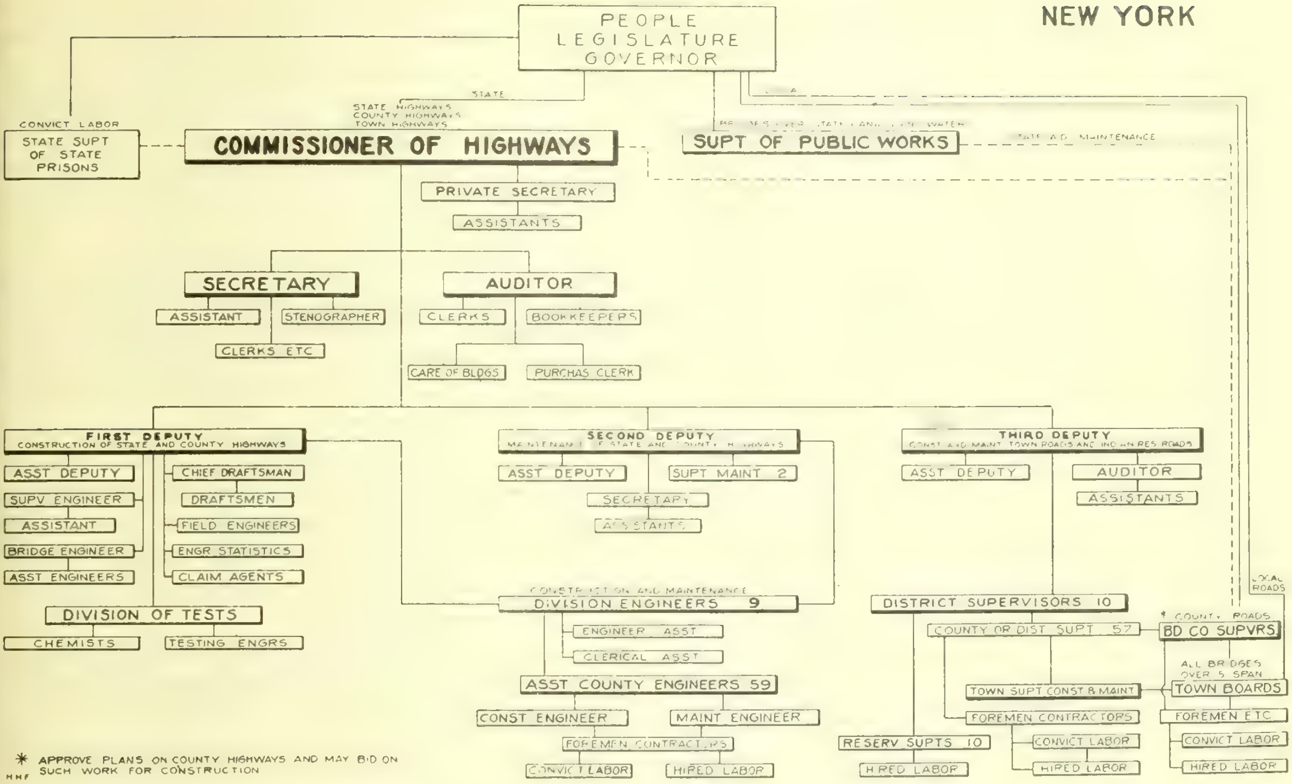
NEW YORK



* APPROVE PLANS ON COUNTY HIGHWAYS AND MAY BID ON SUCH WORK FOR CONSTRUCTION

construction, drafting, inspection, maintenance, and estimates.

The second deputy has charge of maintenance work on State and county highways. He receives a salary of $5,000 per annum, and is assisted by two superintendents of maintenance—one for divisions 1, 2, 4, and 5, and one for divisions 3, 6, 7, 8, and 9. The divisional work under the second deputy is handled as indicated above.

The third deputy has general supervision over the construction and repair of all town roads, highways in Indian reservations, and all bridge work. He is also required to see that towns conform to the State law and keep uniform financial records and to conduct meetings in the different counties to educate the people on highway subjects. He receives a salary of $5,000 per annum and is assisted by a deputy, who has general charge of office and field forces and the work of district supervisors; also an auditor, who has charge of town highway accounts.

For town highway purposes the State is divided into 10 districts, each of which is controlled by a district supervisor. They are traveling representatives of the third deputy, and audit town highway accounts, inspect work, investigate and report on complaints, and exercise general supervision over county and town superintendents and reserve superintendents. There are also seven superintendents who have charge of road maintenance in Indian reservations.

The secretary of the commission is the chief administrative officer under the commissioner. He receives a salary of $5,000 per annum. The secretary has charge of the divisions of estimates, contracts and permits, filing, correspondence and records, and civil service, and transmits general orders throughout the department.

The auditor has supervision over all financial transactions, purchases, supplies, and the care of office buildings.

County organization. In each county there is a board of supervisors whose members are elected by a majority vote of the people. They levy taxes and have general supervision of county roads where such roads exist, and of intercounty and intertown bridges, and under certain conditions may take charge of town roads. A county superintendent is appointed in each county by the board of supervisors for a term of four years. If the county supervisors fail to act, the State highway commissioner may make the appointment from the civil service eligible list of the county and fix the salary. The county superintendents may be removed by the State highway commissioner. The county superintendent represents the county in all State and county highway matters in his county and is required to aid the town superintendents on town road work. Their salaries are paid by the counties, but they report to the third deputy of the State highway department through the district supervisors.

Town organization. There is in each of the 932 towns in the State a town board consisting of at least three members. They are elected each year at the annual town meeting. Town boards are responsible for the proper construction and maintenance of town roads and bridges and for the removal of snow from State and county highways. In each town there is also a town superintendent, either appointed by the town board or elected by the town for a term of two years. He is in direct charge of the maintenance of all town roads and bridges and is subject to the rules and regulations of the State highway department. The town superintendents receive from $2 to $5 per day for time actually employed, and during 1914 the pay roll of such superintendents amounted to $745,000. They report to the third deputy through the county superintendents and district supervisors.

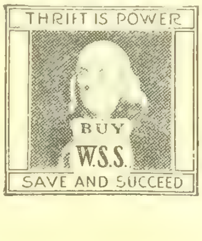
CLASSIFICATION, CONTROL, AND PROCEDURE.

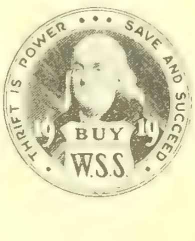
The public roads of New York, comprising approximately 80,000 miles are, for the purpose of fixing responsibility for construction, control, and maintenance divided into four groups, namely, State highways, county highways, county roads, and town highways. The State and county highways together constitute the State system and the town highways belong to that class of local roads which are aided and supervised by the State. In county roads the interest of the State is slight.

State highways.—These are roads over which the State has absolute jurisdiction and for which it pays the entire cost of construction and maintenance, except that the towns are taxed $50 per mile per annum and villages 1½ cents per square yard for portions of such highways located within their respective corporate limits. The system consists of 3,772 miles and includes 46 routes prescribed by the legislature. Up to the close of the calendar year 1917 there had been completed or under contract 2,621 miles of State highways.

In designating these routes the legislature fixed the termini, the intermediate points, and in some cases the exact location, but in most cases the exact location was left to the State highway commissioner. Bridges and culverts over 5-foot span are not included as a part of the highways and must be provided by the towns. Rights of way must be furnished by the counties.

The highway department is required to arrange for an equal amount of work in each county each year, taking into consideration the mileage of State and county highways already completed, and the mileage which remains to be completed. State convicts may be used by the superintendent of State prisons upon requisition of the State highway commissioner on State and county highways, and, if so used, the State highway commissioner shall compensate the prison department for the use of such convicts at a rate based on the value of the labor performed.





County highways. These are roads which are constructed by the State at the joint expense of the State and county. The county highway system is designated by the State highway commissioner. At present there are 8,515 miles in the system, of which 5,362 miles were surfaced or contracted for at the close of the calendar year 1917. Although this system has been designated by the State highway commissioner, the initiative for construction lies with the county boards of supervisors. Bridges, culverts, and rights of way must be provided in the same manner as on State highways.

All surveys, plans, specifications, and estimates are prepared by the State, and contracts are let by the State after plans and estimates are approved by the board of county supervisors, but contracts may be let to towns.

The counties pay variable proportions of the total cost of county highways, arrived at as follows: (1) The total assessed valuation is divided by the total mileage of all roads outside of cities and incorporated villages which gives the assessed valuation per mile; (2) the assessment for county highways is 2 per cent of such assessed valuation per mile, provided that the amount paid by the county in any case shall not exceed 35 per cent of the total cost. Thus the county pays from 8 to 35 per cent of the cost, while the State pays the balance. If the boards of supervisors agree, however, the county may pay 50 per cent of the cost. The costs of surveys and engineering are apportioned and paid in the same manner as for construction. Upon completion the roads are maintained by the State, the maintenance cost being paid in the same manner as for State highways.

County roads.—These roads are built at the sole expense of the counties usually from bond issues, and are subject to the jurisdiction of the county board of supervisors. Approximately 1,000 miles of county roads have been constructed. They are maintained by the county, with local funds provided for the purpose.

Town highways.—The town highways comprise all the roads which are outside the limits of incorporated villages and cities and which do not belong to the State and county highway systems or are county roads. The total length of town highways including roads in Indian reservations is 67,125; of this mileage it is estimated that approximately 12,000 miles have been surfaced up to January 1.

1918. Town highways are constructed and maintained at the joint expense of the State and towns, but no State aid is given on bridges and culverts of over 5-foot span.

All construction work costing over $500 may be let under contract awarded by the town superintendent, in accordance with plans, specifications, and estimates furnished by the district superintendent or the county superintendent. All such work is done under the direction of the district or county superintendent. The improvement and repair of town highways, whatever the cost, may be done without letting the work to contract.

REVENUES.

State.—Appropriations are made annually by the legislature for State and county highways and for aid to the towns on town highways, as well as for the maintenance and support of the State highway department. The funds appropriated for the construction of State highways and for the State's share of county highways are derived from State bond issues. Theoretically, one-half of the funds derived from the registration and licensing of automobiles are used for the construction and maintenance of State and county highways, but as a matter of fact the funds are deposited in the State treasury and thereby lose their identity before being appropriated by the legislature. Furthermore, the amounts annually appropriated for maintenance are usually larger than the amounts derived from the automobile registration fees fund.

On March 30, 1917, there was appropriated and made immediately available $4,525,000 for maintenance, repair, and reconstruction of improved State and county highways, of which $4,075,000 was deposited with the various counties and $450,000 as a contingent fund deposited in the State treasury subject to the requisition of the State highway commissioner.

An appropriation was also passed by the legislature and became a law on April 19, 1917, for the following purposes:

For State aid to towns to be distributed on the basis of taxes levied by the towns for repair and improvement of town highways, etc	$1,980,000
For contributions to counties containing Indian reservations to be apportioned on basis of not less than $30 per mile of road	50,000
For construction and improvement of county roads in Franklin County	20,000
Total	2,050,000

In order to receive State aid from the above appropriation, it is necessary for the town to levy a tax to be paid in cash of such amount that when it is added to the contribution by the State it will equal $30 per mile for all roads outside the limits of all incorporated villages and cities. For towns having a valuation of less than $3,750 per mile there has been established a lower requirement, which is $4 per thousand of assessed valuation.

The amount which a town may receive from the State is regulated both by the appropriation of the town for roads outside of incorporated cities and villages, exclusive of bridges and culverts over 5-foot span, and its wealth per mile of road, and is determined by adding to the town appropriation a percentage which decreases with the increase in the valuation. If the valuation of the town is less than $5,000 per mile the State will pay 100 per cent of the taxes so raised; if it is between $5,000 and $7,000 the State pays 90 per cent; if between $7,000 and $9,000 the State will pay 80 per cent; if between $9,000 and $11,000 the State pays 70 per cent; if between $11,000 and $13,000 the State pays 60 per cent; and if over $13,000 the State will pay 50 per cent.

In other words, the aid from the State varies from one-third to one-half the expenditure by the town inversely with valuation per mile of roads outside the limits of incorporated cities and villages. Thus the State extends a greater amount of aid to the poorer towns than to the richer ones. There is a further limitation in the law which provides that no allowance by the State shall exceed $25 per mile except where the valuation per mile is greater than $25,000, when one-tenth of 1 per cent of that valuation may be allowed.

An appropriation was made by the legislature and became a law April 27, 1917, providing $300,000 with which to meet the Federal aid apportionment for the fiscal year ending June 30, 1917. An additional appropriation was also made of $100,000, which constitutes a revolving fund to be repaid by the Federal Government out of Federal aid appropriations for the State. This will enable the State to pay the entire cost of its Federal aid projects as the work progresses and to be reimbursed by the Federal Government to the extent of 50 per cent of the total cost when the contracts have been completed and accepted.

A reappropriation of unexpended balances for the construction of State and county highways was made during 1917, amounting to $7,126,947.63. This appropriation was originally made from the proceeds of the second bond issue, amounting to $50,000,000, authorized in 1912.

On June 5, 1917, an emergency appropriation of $100,000 was made by the legislature for repair and maintenance of improved State and county highways on principal routes between New York and Albany. A special appropriation was also made for State routes in Green County and for other work on State and county highways, amounting to $346,636.69.

The funds appropriated during the early part of 1917 may be briefly summarized as follows:

For maintenance, repair, and construction of State and county highways, and for administrative and field expenses on the same	$4,575,000.00
For State aid to towns and Indian reservations, etc	2,050,000.00
For State's share to meet Federal aid	400,000.00
Reappropriation for construction of State and county highways	7,126,947.63
Special appropriation for construction of State and county highways	346,636.69
For repair and maintenance of State and county highways between New York and Albany	100,000.00
For State highway department, central office, fiscal year beginning July 1, 1917	294,683.00
For construction of highways under superintendent of State prisons	50,000.00
Total	14,943,267 32

Local revenues.—Taxes for town roads to which State aid is extended and for bridges over 5-foot span, to which no State aid is extended, and for other town-road purposes are levied by the board of county supervisors on the recommendation of town boards. The funds so raised by the towns, exclusive of funds received from local bond issues and from State-aid appropriations, amount to approximately $6,000,000 per annum.

To pay the county's share of the cost of county highways the boards of county supervisors are authorized to levy and collect a tax apportioned between the county at large and the town or towns in which such highways are constructed. The money so raised may also be used to pay interest and principal on county highway bonds.

BONDS.

State.—The construction of State and county highways has been financed largely by State bonds, of which $50,000,000 were authorized in 1906 and $50,000,000 in 1912. The funds derived from the sale of bonds are deposited in the State treasury and are appropriated out as needed. All of the first issue and $30,000,000 from the second issue have been sold and the proceeds appropriated. All of the bonds are of the sinking-fund variety, and run for 50 years. They bear rates of interest varying from 3 to 4½ per cent.

Each year the legislature levies a State-wide tax, the proceeds from which are deposited in the State treasury for the payment of interest and for the creation of a sinking fund to retire the bonds at maturity. Out of the sinking fund thus created the legislature appropriates each year the amount required to pay interest on the bonds outstanding. For 1917 there was appropriated for this purpose $3,320,000.

Local bonds.—Towns may borrow money in anticipation of taxes, or the county boards of supervisors may authorize towns to issue bonds for highway or bridge purposes, provided the proposition has been agreed to by a majority vote of the town meeting. The county board of supervisors fix and levy on the towns which have issued bonds a tax sufficient to pay interest and to retire the bonds when they become due. It appears to be discretionary with the town and county boards to fix the term, interest rates, amounts, and character of bonds to be issued.

The county boards of supervisors may by resolution authorize the issuance and sale of town and county bonds in amounts not to exceed 35 per cent of the cost of county highways. The term of such bonds is limited to 30 years, and a tax is levied upon the whole county or upon the various towns benefited for the payment of interest and principal.

NORTH CAROLINA.

DEVELOPMENT.

State participation in road work in North Carolina is limited to educational, advisory, and supervisory work, and money aid to counties for the maintenance of roads included in the State system of highways administered by a State highway commission. The State extends advice and supervision to counties and townships on request, and has superintendence and control over the maintenance of State highways.

The State controls, through the distribution of the automobile fund, about 4.3 per cent of all expenditures and has authority over maintenance of the State system, which includes about 6.6 per cent of the total road mileage of the State.

In 1909 the legislature appropriated $5,000 per annum to enable the economic and geological survey to conduct road investigations, make experiments, and furnish advice to local officials on road problems. This work was continued by the geological survey until 1915, when the State highway commission was created and provision was made for the designation of the tentative State highway system connecting county seats and principal cities of the State. In 1917 the legislature provided that all net receipts from automobile registration be expended for maintenance of the State system under the direction of the State highway commission.

Of the 50,758 miles of road in the State, it is estimated that on January 1, 1915, 6,750 miles, or 13 per cent, were surfaced, principally with sand-clay. The total expenditures for all road and bridge pur-

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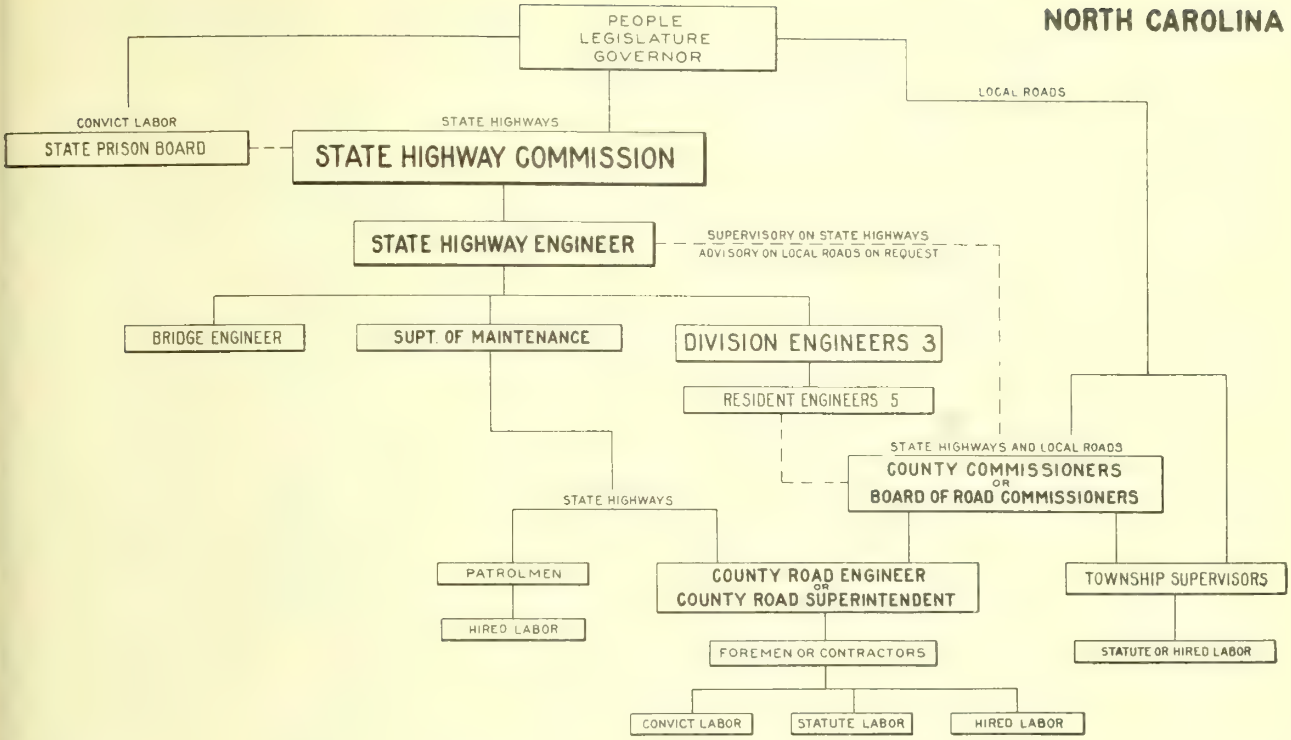


poses were estimated to be about $5,500,000 for the year 1916. During 1917 there was expended by all forces of the State for highway purposes $5,520,000.

ORGANIZATION.

The road forces of the State and the relation existing between them is shown on the diagram herewith.

State.—The State highway commission consists of seven nonsalaried members, three appointive and four ex officio. The appointive members are appointed by the governor for terms of four years, one from eastern, one from central, and one from the western part of the State, and one of whom shall belong to the minority political party of the State. The ex officio members consist of the governor, State geologist, a professor of civil engineering in the University of North Carolina, and a professor in the North Carolina Agricultural and Mechanical College, the professors being designated by the governor. The State highway commission appoints and fixes the salary of a State highway engineer and such other employees as may be needed. The commission also acts in a consulting capacity to the State highway engineer on all engineering problems confronting him and may call meetings to be held in various parts of the State to be conducted by the State highway engineer.

The State highway engineer who is the administrative head of the work of the State highway commission must be well versed in the science of road building and maintenance. He is appointed for a term of six years. The State engineer is assisted in the discharge of his duties by three division engineers, a bridge engineer, the superintendent of maintenance, and other assistants.

County.—Each county is governed by a board of county commissioners of from three to seven members elected usually for a period of two years. Thirty-seven counties have five commissioners, one county has six commissioners, one has seven, and one county elects its commissioners for four-year terms. The county clerks and treasurers are the clerical and fiscal agents of the county boards, and the sheriff is the tax collector. Except in special cases the county board has charge of the layout, altering, construction, and maintenance of all roads and bridges and the raising of money therefor.

In carrying out road work in the different counties there is considerable variation in organization and procedure. Many counties in which bonds have been issued have boards of county road commissioners who are given power to employ engineers, superintendents, to make contracts, and to buy machinery. In some counties the work is done under the direction of county engineers, in others by county superintendents, while in others the work is done by township supervisors. The township supervisors are elected for two-year terms and have charge of the maintenance of roads and bridges in their respective townships.

There are 25 counties that have county engineers. Such engineers are usually employed by those counties in which extensive improvements are under way, and when the work is being done by contract. In such cases the engineer makes all surveys, prepares plans, specifications, and estimates, acts as inspector, and prepares and approves monthly estimates which are submitted to the county board for payment. County engineers are usually appointed by the county commissioners on the recommendation of the State highway engineer. The county superintendents are usually practical road builders employed in counties where the work is done by force account or with convict gangs. Generally, they are not civil engineers and, therefore, incapable of making surveys, preparing plans, specifications, and estimates.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 50,758 miles of public road are divided for the purpose of fixing responsibility for control, construction, and maintenance into two groups, viz, State highways and county roads.

State highways.—The legislature from time to time has designated certain interstate roads as State highways, viz, the central highway extending from Beaufort Harbor on the Atlantic coast to the Tennessee line, Charlotte-Wilmington highway, the Hickory Nut Gap highway, and the Asheville-Murphy scenic highway. In addition to these the State highway engineer in consultation with the State highway commission is given general authority to designate, lay out, survey, etc., a system of State highways. The tentative system of State highways thus selected, including those specially designated by the legislature, comprises 3,356 miles.

The State provides no money with which to construct these roads, but by special authority of the legislature State convicts have been used in the construction of the central highway and the Asheville-Murphy highway. The net receipts from the registration of automobiles is apportioned to be used in the various counties for the maintenance of roads of this group, such work being done by and under the direction of the State highway engineer. The construction work on State highways is carried on by the counties, except when the State highway engineer is requested to take charge. However, all plans, specifications, and estimates are prepared and paid for by the State, but if the roads are not built in accordance with such plans and specifications, the cost of the surveys, plans, etc., is paid by the counties.

County roads.—These include all roads in the State not included in the State system. They are built and maintained by county and township authorities with county or township funds. The State has no jurisdiction over roads of this group except on request of local authorities. The State highway engineer will, on request, prepare plans, specifications, and estimates, but if the roads are not built in accordance with such plans, the cost of such work is paid for by the county. County prisoners may be used in the construction and maintenance of roads of this group.

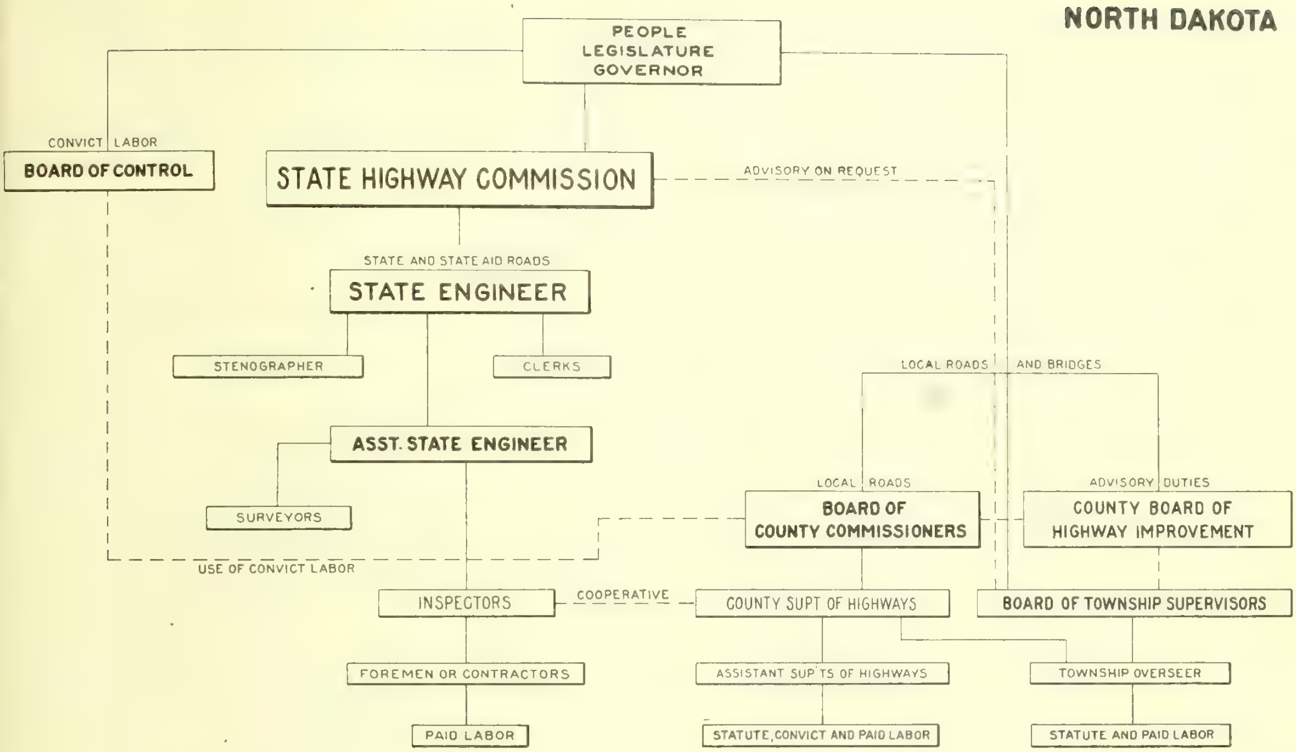
REVENUES.

State funds for the support of the State highway commission are derived from an appropriation of $20,000 per annum. The gross receipts, less not to exceed 12½ per cent for collection, derived from the registration of automobiles are expended for the maintenance of State highways and bridges. Of the net receipts 17½ per cent may be expended at the discretion of the State highway commission and 70 per cent is apportioned to the counties from which collected, but must be expended within one year on the maintenance of State highways by and under the direction of the State highway commission. The amount available for this fund for the fiscal year ending June 30, 1918, is estimated at $275,000.

County.—Road and bridge taxes in the counties vary from 5 to 50 cents per $100 of valuation and from 45 cents to $1 per poll. Some counties also retain the statute labor system. It is estimated that during 1916 there was expended from local funds a total of $5,500,000.

BONDS.

State.—The legislature of 1917 provided that the State treasurer should issue State bonds in amounts not to exceed $800,000 a year during the next 41 years, the proceeds to be used as a loan fund to the counties for permanent road improvement. The bonds are to bear 4 per cent interest. The counties benefiting by the act are to annually pay the interest plus 1 per cent of the amount borrowed. The additional 1 per cent is to be used by the State for creating a fund with which to retire the bonds in 41 years from the date of issue. Counties desiring to borrow a portion of the State bond fund are required to submit the question to a popular vote. If a majority decides in favor of making use of the State money, a special tax is levied by the county which must be sufficient to pay the interest on the bonds at 5 per cent plus 4 per cent of the bonds so used for the first four years from the date of issue, 8 per cent for the subsequent four years, and 10 per cent thereafter so long as the bonds remain unpaid to the State. The additional 4. 8, and 10 per cent referred to are levied for the purpose of maintaining the roads so constructed. County officials failing to levy or collect such taxes shall be guilty of a misdemeanor. State loans to any county when added to the existing indebtedness shall not exceed 6 per cent of the assessed valuation of the county. No State supervision or inspection of the roads constructed from these funds is provided for, and so far none of the bonds have been issued.



Counties and townships may issue bonds for road or bridge improvement in amounts not to exceed 10 per cent of the taxable valuation of the property. Before such bonds are issued the question must be submitted to the qualified voters of the county or township and a favorable vote returned by a majority of the voters, but before such election can be held the State highway engineer must certify that the proposed issue will be sufficient for the purposes set forth in the petition for the election. The term, character and interest rate of the bonds are left to the discretion of the authorities issuing them. In case the bonds are issued, special taxes must be levied in sufficient amounts to pay interest and principal and to maintain the roads so constructed. The tax for maintenance shall not be less than 1 per cent nor more than 4 per cent of the bonds issued. The total of county and township bonds outstanding on January 1, 1915, was $8,955,300. A large mileage of the improved roads of North Carolina has thus been financed from bond issues.

NORTH DAKOTA.

DEVELOPMENT.

State participation in road and bridge work in North Dakota is of recent origin, limited in amount, of State-wide distribution, and is administered by a State highway commission.

State interest in and aid to road and bridge work began in 1909 with the establishment of a good roads experiment station for the purpose of constructing experimental roads. Due to a lack of sufficient funds the desired work was not fully accomplished. Beginning in 1911 the net automobile revenues were returned to the various counties for use by the county authorities in maintaining the main traveled roads of the State, and this policy was continued until 1917.

In 1913 a State highway commission was organized and accomplished during the next three years considerable educational work along the lines of road and bridge improvement. No funds were provided during this period to enable the State to take part in construction or maintenance, although the commission furnished at the expense of the counties applying therefor engineers to execute surveys of and prepare plans, specifications, and estimates of cost for a number of road and bridge projects.

In 1916 the State highway commission was reorganized to meet the requirements of the Federal aid road act, and provision was made for the designation of a system of State roads comprising about 4,000 miles or 5.8 of the total road mileage of the State to be constructed at State and local expense under the supervision of the State highway commission.

On January 1, 1917, 1,100 miles, or 1.6 per cent, of the total road mileage of the State was reported surfaced. During the year 1916, $2,711,295 was expended by local officials for road and bridge purposes. The State highway commission, being possessed at this time of educational and advisory powers only, did not supervise any part of this expenditure.

During 1917 there was expended by all forces for highway purposes a total of $2,868,000.

ORGANIZATION.

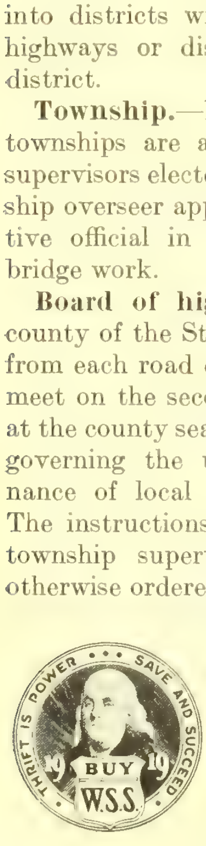
The organization of the highway forces of the State and the relation existing between them is shown on the diagram.

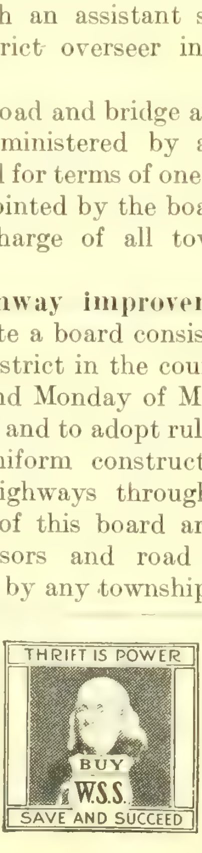
State.—The State highway commission, composed of the governor of the State as chairman, the State engineer, the commissioner of agriculture and labor, and two members appointed by the governor, has charge of the location, construction, and maintenance of all projects financed wholly or in part with Federal or State funds. The State engineer as secretary and engineer of the commission is the executive officer of the commission in all matters relating to construction and supervision of maintenance of State projects and is required to furnish advice to local road and bridge officials when requested by them. He is provided with assistant engineers, stenographer, and three inspectors.

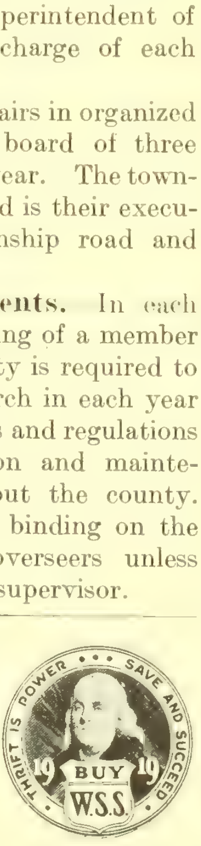
County.—The road and bridge affairs are administered by a board of county commissioners consisting of three or five members elected for terms of four years. The county auditor and county treasurer are respectively clerk and fiscal agent of the board. County boards may appoint a county superintendent of highways skilled in road and bridge building who serves as their executive official. Counties not organized into townships are divided into districts with an assistant superintendent of highways or district overseer in charge of each district.

Township.—Road and bridge affairs in organized townships are administered by a board of three supervisors elected for terms of one year. The township overseer appointed by the board is their executive official in charge of all township road and bridge work.

Board of highway improvements. In each county of the State a board consisting of a member from each road district in the county is required to meet on the second Monday of March in each year at the county seat and to adopt rules and regulations governing the uniform construction and maintenance of local highways throughout the county. The instructions of this board are binding on the township supervisors and road overseers unless otherwise ordered by any township supervisor.







CLASSIFICATION, CONTROL, AND PROCEDURE.

The 68,796 miles of public road of North Dakota are, for the purpose of fixing responsibility for control, construction, and maintenance, divided into two groups, viz, State roads and county roads.

State roads.—These comprise about 4,000 miles of main traveled roads selected by the various county boards, with the approval of the State highway commission for improvement at their joint expense. This system may be increased by agreement between the county board having jurisdiction over the road concerned and the State highway commission.

Initiative for construction or improvement of a road of this group is taken by the county board by making application to the State highway commission for aid in carrying out the proposed improvement. When favorably considered by the State highway commission, surveys are executed and plans, specifications, and estimates of cost are prepared by the State engineer. Proposed improvements costing less than $3,000 may at the discretion of the commission be executed by force account by the State engineer or by the county board, or may be let by contract. Work costing more than $3,000 is required to be advertised for bids. The bids may be rejected and the work done by force account under the direction of the State engineer or contract may be awarded by the State engineer with the approval of the county board concerned.

The work during progress is under the supervision of the State engineer. Monthly payments for the work completed are made by the State and county officials, the payments being based on an estimate prepared by the representative of the State engineer in charge of this work. Fifty per cent of the cost is paid by the State when the estimate has been approved by the State engineer and the secretary of the State highway commission. The county's share of the cost is paid by the county board when the estimate has been approved by the State engineer and the county superintendent of highways if such official has been appointed by the county board.

Final payments are made in a similar manner when the completed work has been accepted by the State engineer.

Completed roads of this group are maintained by the counties at the joint expense of the State and county subject to the inspection and supervision of the State engineer.

County roads.—These comprise all other roads of the State. They are constructed and maintained by county or ownship officials with local funds. A large measure of control is given to these boards over tax rates and location and construction of new roads.

REVENUES.

State.—For the year 1917 the legislature has provided an appropriation of $8,000 as emergency funds for the partial support of the State highway department. The State highway fund composed of two-thirds of the net receipts of the motor vehicle fund is available for expenditure by the State highway department as follows:

(*a*) For the support of the State highway department.

(*b*) For contributions to the maintenance of roads improved under the State-aid plan.

(*c*) For expenditures for road and bridge purposes in the various counties of the State, Of this latter amount 10 per cent of the funds may be expended at the discretion of the State highway department. The remaining 90 per cent is expended in the counties in the ratio in which the tax is paid. A total fund accruing from motor vehicle licenses available for expenditure by the department during 1917 amounted to $105,707.82. This will be increased to about $186,000 by an increase in the rate.

County.—One-third of the net motor revenues amounting to $72,162.14 was returned to the counties in which they are collected and credited to the funds for repair and dragging of highways within the county. County taxes are levied at the following rates:

Poll tax, $1.50 a year, or in lieu thereof one day's labor on the roads is required from each male inhabitant between the ages of 21 and 50.

A bridge tax at a rate not exceeding 4 mills on the dollar, and a road tax at a rate not exceeding 4 mills on a dollar to be paid in money or labor at the rate of $1.50 per day and an emergency tax at a rate not exceeding 2 mills on the dollar may be levied by the county board.

Township.—Township boards may levy a tax for road and bridge purposes at a rate not exceeding $1 on each $100 of assessed valuation. A portion of this tax levied for road purposes may be worked out by the taxpayers at the rate of $1.50 a day.

BONDS.

No bonds have been issued by the State or counties for road and bridge purposes.

OHIO.

DEVELOPMENT.

State participation in road improvement in Ohio consists of money aid in the construction and maintenance of a State-wide system of intercounty highways and main market roads known after improvement as State roads, administered by the State highway department. The system of intercounty highways includes 9,875 miles, of which 2,775 miles are main market roads. State control extends to about 11 per cent of the total road mileage of the State and the State contributes approximately 28.5 per cent of all road expenditures.

The first State-aid law enacted in 1904 provided for a State highway department and for State aid to roads, but no appropriation was made. The cost of State-aid roads was to be borne as follows: 25 per cent by the State, 50 per cent by the county, 15 per cent by the township, and 10 per cent by the abutting property. In 1905 the first appropriation of $10,000 for State aid and $7,400 for the highway department was made. The State-aid money was to be equally apportioned among the 88 counties. The fund was so small when so apportioned that no applications were made for aid during the first year.

The State-aid appropriation was increased to $150,000 in 1906 and 1907, to $440,000 in 1908, to $486,577 in 1909, and $558,654 in 1910. In 1911 the highway department was reorganized. Three deputies and other employees were provided, the State's share of the cost of State-aid roads was increased to 50 per cent, provision was made to have the State pay 25 per cent of the cost of maintenance of roads built under State aid, and a system of intercounty highways was provided for. No material changes have since been made except as follows: A State-wide tax has been provided and moneys derived from automobile registration and licenses are used to pay the whole cost of maintenance of such intercounty highways and main market roads as have been constructed or taken over by the State. In 1912 an attempt was made to amend the State constitution by providing for a bond issue of $50,000,000 for road improvement, but this failed by 2,018 votes out of a total of 547,146 votes cast.

Of the 86,354 miles of public road in the State, it is estimated that 31,500 miles or 36.5 per cent were surfaced on January 1, 1917, and that during the year 1916 approximately $2,800,000 was expended by the State and $10,000,000 by the counties and townships including their contributions to meet State aid.

During 1917 there was expended by all forces of the State for highway purposes a total of $12,000,000.

ORGANIZATION.

State.—At the head of the State highway department is a State highway commissioner appointed by the governor, with the advice and consent of the senate, for a term of four years. He receives a salary of $4,000 per annum.

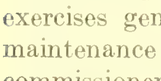
There is a nonsalaried bipartisan advisory board consisting of four members appointed by the governor for terms of four years, one being appointed each year. All official acts of the State highway commissioner in connection with the designation of intercounty highways or main market roads, the granting of aid, the letting of contracts, the purchase of materials, tools, and equipment, the entering into agreement with the Federal Government on post-road projects, and the designation of engineers other than county surveyors to take charge of road and bridge work within any county under control of the State, must first have the approval of the advisory board. The State highway commissioner is ex officio secretary of the advisory board.

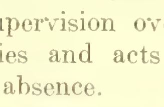
The State highway commissioner has general supervision over the construction and maintenance of intercounty highways and main market roads and must approve plans and specifications for all bridges on other roads if the cost exceeds $10,000. He causes to be prepared plans, specifications, and estimates for any road, culvert, or bridge on request. He may conduct investigations, propaganda work, and make experiments.

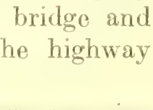
The engineering work of the department is conducted under the direction of three deputies appointed by the commissioner. One of these deputies is designated as chief highway engineer and has charge of all matters relating to the design and construction of roads. One is designated as the maintenance deputy and has charge of all maintenance and repair work, while a third is designated as bridge deputy and has charge of all matters pertaining to the design, construction, and maintenance of bridges. Each deputy receives a salary of $3,000 per annum. The construction deputy exercises general supervision over the bridge and maintenance deputies and acts for the highway commissioner in his absence.

Acting under the three deputies there are nine division engineers appointed by the commissioner from the civil-service eligible list. They have their headquarters at the central office in Columbus, but most of them live in their own districts. They have charge of design, construction, and maintenance of roads and bridges in their respective divisions.

The county surveyors of the various counties are by virtue of their positions resident engineers of the State highway department. If such county surveyor fails to comply with the requests of the State highway commissioner, he may be removed as the representative of the State. The State pays one-fifth of his salary as long as he represents the State as resident engineer.







Correspondence, records, and accounts at the central office are handled by the chief clerk appointed by the commissioner. Civil-service and legal matters are handled by the secretary to the commissioner, who is an attorney. The physical and chemical testing work of the department is handled by a testing engineer, a chemist, and assistants.

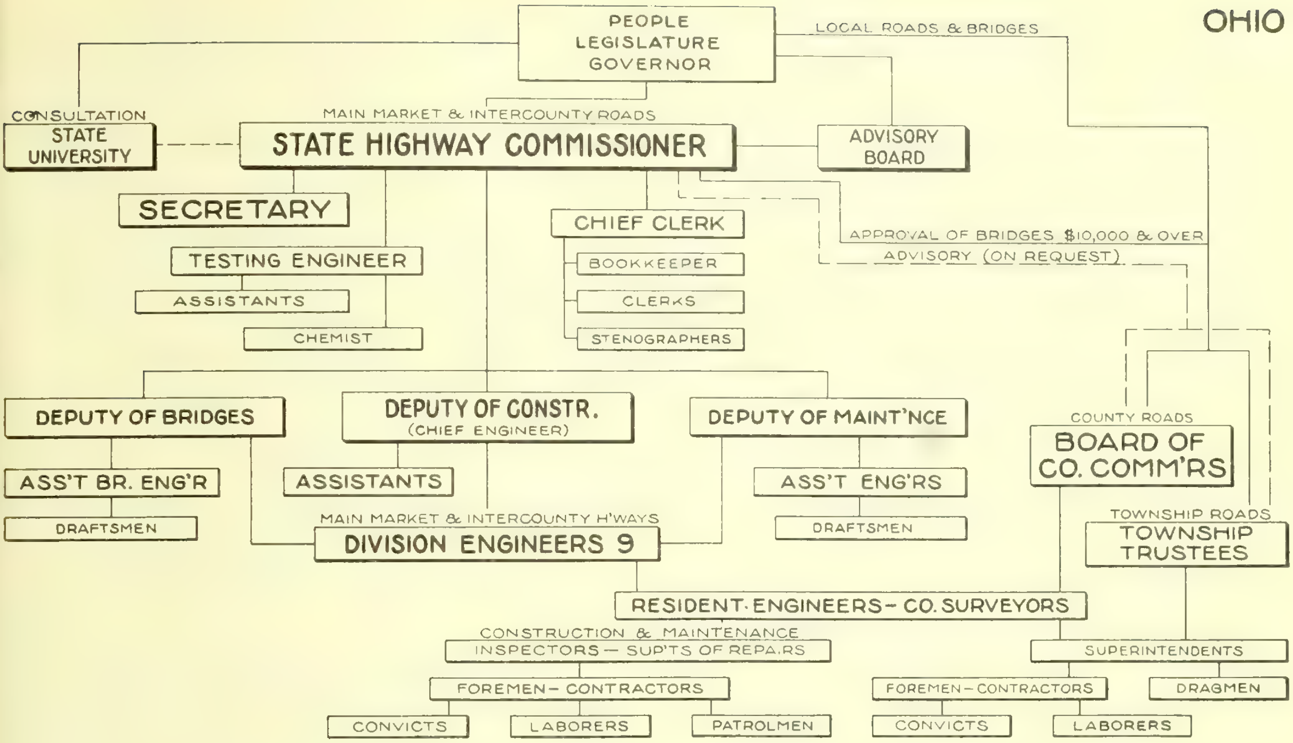
County organization.—Highway matters in the various counties are handled by a board of county commissioners consisting of three members, elected biennially for a term of two years. The county auditor is the clerk of the board except in the larger counties, and the county treasurer is the custodian of the funds. Under the direction of the county commissioners, the county surveyor has charge of the design, construction, and maintenance of all county roads. As indicated above, he may also represent the State as resident engineer. His salary is paid one-fifth by the State if he acts for the State, and four-fifths by the county on a basis of road mileage and population, the maximum being $6,000 per annum.

Township.—Highway matters are handled by the township trustees, of which there are three in each township elected biennially for a term of two years. They divide their townships into three districts, each having charge of his district, or they may appoint one of their own members or a person not on the board as highway superintendent for the township. The township trustees of any township may order the county surveyor to prepare plans, specifications, and estimates for roads to be constructed or resurfaced, or the county surveyor may on his own motion prepare such alternate plans, specifications, and estimates, and when the same have been approved by the township trustees, the work may be let by contract by the trustees on the lump-sum or unit-price basis. Such contract work is done under the general direction of the county surveyor.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Ohio comprising 86,354 miles are for the purpose of fixing responsibility for construction, control, and maintenance divided into three groups, namely, State roads, county roads, and township roads.

State roads.—These are such portions of intercounty highways and main market roads as have been constructed by the State with State money, or which have been taken over by the State. There are 492 intercounty highways embracing 9,880 miles, forming a continuous system throughout the State. These roads were selected by the State highway department, and were legally adopted by the governor's approval in December, 1912. From the system of intercounty highways, the legislature in 1913



designated 12 main market roads. This number has since been increased by the State highway commissioner with the approval of the governor to 22, and includes 2,775 miles of the intercounty highway system.

Applications for State aid on intercounty highways originate with the county commissioners or township trustees. Plans, specifications, and estimates are prepared by the county surveyor or resident engineer, checked and approved by the division engineer, and forwarded to the State highway commissioner for approval. If approved, he forwards the same to the county or township and when approved by the county or township, the same is returned with statement showing that the necessary financial arrangements have been completed, and that necessary rights of way, gravel pits, stone and quarries, have been secured by condemnation or purchase. Contracts are let by the State highway department in the name of the State and approved by the county or township. Work proceeds under the direction of the county surveyor or resident engineer, and inspectors appointed by the county surveyor who must be State civil service eligibles approved by the State highway commissioner. The work is inspected at frequent intervals by the division engineer. Payments are made on monthly estimates deducting 15 per cent until final completion and acceptance.

The above procedure is followed in the construction of intercounty highways and main market roads, when the counties or townships cooperate. When they do not cooperate, the State highway commissioner may proceed with the work without local initiative.

When the State is cooperating with the county in the building of a State road ordinarily the percentages paid by the State, county, township, and property owners are as follows: State not to exceed 50 per cent, county 25 per cent, township 15 per cent, and property owners 10 per cent. If the State does not pay 50 per cent the balance is usually made up by the county. When the tax duplicate (assessed valuation) of a county is less than $30,000,000, but not over $20,000,000 the State may pay not to exceed 60 per cent. When the tax duplicate is less than $20,000,000 the State may pay not to exceed 75 per cent. The county may assume the township's share, or the township may assume the county's share. When the State is cooperating with the township in the building of a State road, the State may pay not to exceed 75 per cent of the cost.

Under all conditions the property owners are required to pay not less than 10 per cent of the total cost, but they may be assessed in any amount above this at the will of the county commissioners. The assessment of property owners may be made on the front footage of abutting property or by unanimous vote of the county commissioners on property within one-half or 1 mile of the road. No part of the cost of bridges and culverts is assessed against the township or property owners. The cost of culverts and bridges is paid by the State and county in the same ratio as for construction of the road. If the State acts independently of the county and township, the State pays the entire cost less the amount contributed by the property owners, which must in no case be less than 10 per cent.

On January 1, 1918, 2,029.61 miles of intercounty highways and main market roads had been surfaced or contracted for by the State, and 144.33 miles of county and township roads had been taken over by the State making a total of 2,173.94 miles of State roads.

These roads when completed are turned over to the maintenance deputy and are maintained by the State at State expense, but a portion of the cost of maintenance may be paid by a county or township. The State may take over an intercounty highway or main market road previously constructed by a county or township and thereafter pay the cost of maintenance. The maintenance work is carried on under the immediate direction of the county surveyor. Weekly reports are made to the maintenance deputy by the superintendents, patrolmen, and foremen. The patrol or gang system of maintenance is employed, a general tendency being to use the gang system.

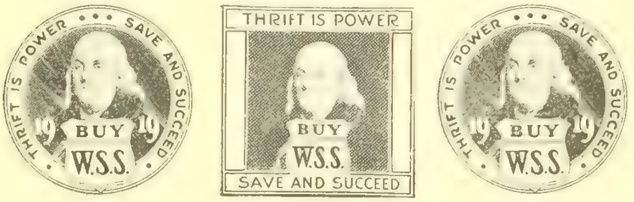
State convicts may be used by the highway department through requisition on the State prison authorities in improving intercounty or main market roads, or in preparing materials therefor. The cost of transportation, guarding, clothing, and other expenses incident to such work may be paid by the State highway department from funds available for the construction of State roads.

County roads.—The county roads may be said to include all roads that are not State roads, but which have been or may be surfaced with hard materials to a standard fixed by the county commissioners. All such roads are maintained by the county commissioners.

Township roads.—These include all highways except those above indicated and are under the jurisdiction of the township trustees.

REVENUES.

State.—A State-wide tax of three-tenths of a mill is levied annually from the proceeds of which 75 per cent is used for the support of the State highway department and for the construction of intercounty highways, and 25 per cent is used for the construction of main market roads. After deducting from the 75 per cent fund enough to support the State highway department, the balance is apportioned equally among the 88 counties. The 25 per cent fund is apportioned at the discretion of the State highway commissioner in such a way as to distribute equitably and as far as practicable the benefits from such expenditures to the different sections and counties of the State.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The net receipts from the registration of automobiles is used for the maintenance of State roads. The receipts from the State tax and the automobile fund are deposited in the State treasury and are appropriated out as needed.

Appropriations for the fiscal year ended June 30, 1918, are as follows:

State highway department	$113, 960
Construction of intercounty highways	[1] 1, 563, 270
Construction of main market roads	[1] 537, 400
Reappropriation of surplus	900, 000
Maintenance and repair of intercounty highways, and main market roads	1, 749, 960
Total	4, 864, 590

Local revenues.—For highway construction the county commissioners may levy not to exceed 2 mills on all property, including cities, and villages, for maintenance of roads and bridges. The county commissioners must levy a tax which will produce at least $20 for each mile of county roads. For the county's share of the cost of State roads, the counties may levy a tax of not to exceed 1 mill. County roads may also be improved under the local assessment plan on petition of 51 per cent of abutting landowners, and the whole or a portion of the cost may be assessed by the county commissioners against the abutting landowners within one-half to 2 miles of the road, in proportion to benefits received, or a portion of the cost not to exceed 50 per cent may be paid by the county and township. In order to meet the township's portion of such cost, the county commissioners may levy a tax of not to exceed 3 mills on the township or townships.

Township.—The township road funds are derived from a tax of not to exceed 3 mills levied by the township trustees, but an additional levy of 2 mills may be made for meeting the township's share of State roads. Township roads may also be improved on the local assessment plan on petition of owners of real estate. If petitions are granted by the township trustees from 25 to 50 per cent of the cost may be assessed against the abutting property owners within one-half or 1 mile of either side and termini of the road.

It is estimated that counties and townships expended from local revenues approximately $7,000,000 during 1916, exclusive of about $3,000,000 for the construction of State roads.

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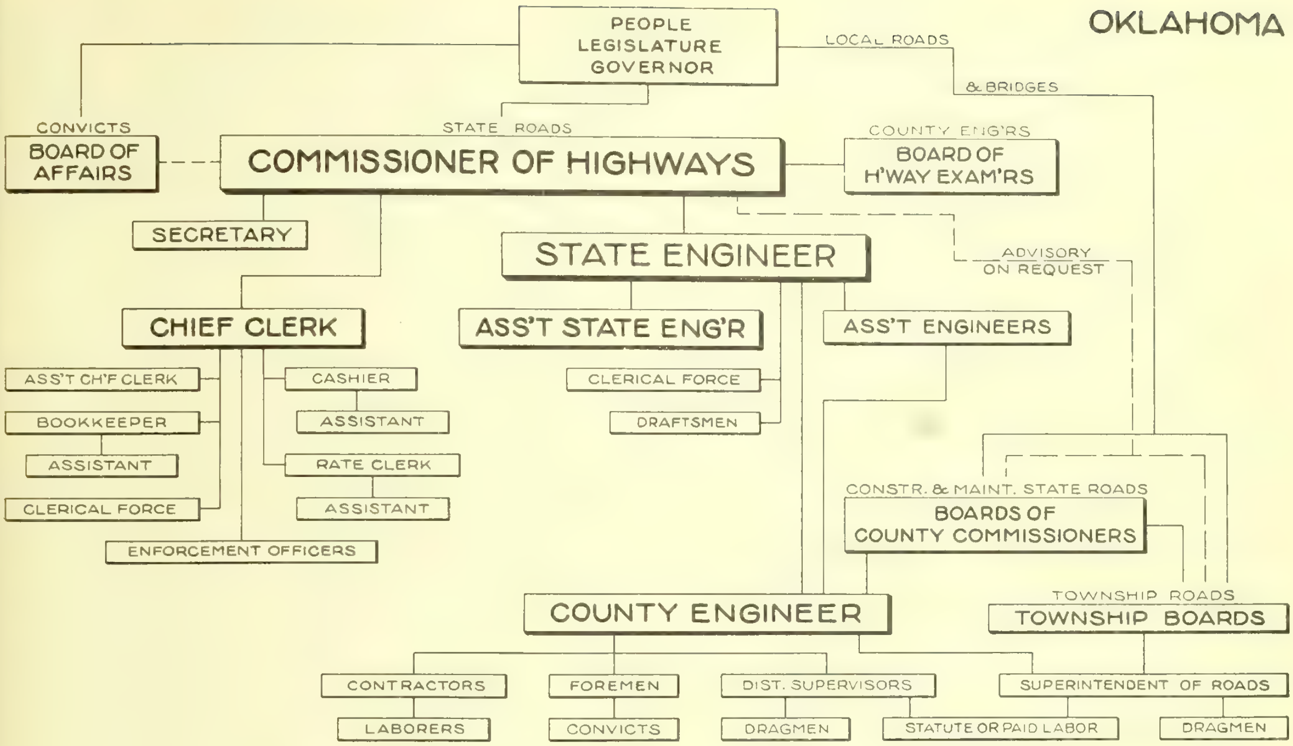
[1] One-half of the amount appropriated for two years.



BONDS.

In anticipation of the collection of taxes or assessments to meet the county's or township's share of State roads or county roads built under local assessment plan, the county commissioner may issue sinking-fund bonds maturing in not to exceed 10 years and bearing not to exceed 5 per cent interest. The aggregate amount of such bonds for State roads shall not exceed 1 per cent of the tax duplicate (assessed valuation).

For the construction of township roads, the township trustees may issue bonds maturing in not more than 10 years and bearing not to exceed 6 per cent interest, provided the same is agreed to by a majority of the electors; the amount to be issued is left to the judgment of the township trustees.

For many years counties and townships have indulged rather freely in bond issues, and on January 1, 1915, there was a total of upward of $31,000,000 of such bonds outstanding, and during the year 1914 there was expended from bond issues $6,000,000, while there was retired about $2,700,000.

OKLAHOMA.

DEVELOPMENT.

With the appointment of a State highway commissioner in 1911 with educational and advisory duties, State interest in road and bridge work was first manifested, and during the period 1911 to 1915 considerable data relative to road improvement, road finances, etc., was collected and published at State expense by the commissioner.

In 1915 a State department of highways was organized. By the terms of legislation passed in 1916 its powers and duties were increased. A system of State roads selected by the boards of commissioners of the various counties of the State was authorized by the legislature at this time and in 1917 supervisory control over the location and plans for all improvements made on this system was vested in the department of highways.

The system of State roads is required to comprise not less than 10 nor more than 15 per cent of the total road mileage of each county and is selected to insure connection between the principal towns of the State.

A one-fourth mill State tax levy was made in 1916 on all property in the State and the proceeds thereof were returned to each county in the ratio of tax paid, provided that the county levied a similar tax and that the joint fund was expended in accordance with plans approved by the department of highways.

During 1916, 1,900 miles of road were improved under State supervision. It would appear, however, that a large portion of the work accomplished consisted of grading earth roads, as at the close of this period only 300 miles were reported as surfaced.

The expenditure of $300,000 of State funds and of $1,825,000 of local funds by or under the supervision of the department of highways comprised 58.5 per cent of the total expenditure, $3,625,000, made by all road and bridge forces of the State during the year 1916.

During 1917 there was expended by all road forces of the State for highway purposes a total of $3,722,000.

ORGANIZATION.

The organization of the highway forces of the State and the relation existing between them is shown on the diagram.

State.—Supervision of highway construction and maintenance is vested in a department of highways in charge of a commissioner of highways, who is appointed by and who serves at the pleasure of the governor and is required to be a practical road builder.

The commissioner of highways has supervision over all matters relating to State roads, is required to determine and establish standards best adapted to the various sections of the State, and to furnish without cost plans and specifications for road and bridge work presented by local officials.

The State engineer and the assistant State engineer are appointed by the commissioner with the consent and the approval of the governor. Other employees necessary for the conduct of the business of the department may be employed by the commissioner.

The commissioner of highways, with the approval of the governor, appoints three civil engineers of established reputation and ability to constitute a board of highway examiners. This board conducts examinations of applicants for the position of county engineer. Certificates of competency are issued by the commissioner to those candidates recommended by the board. These certificates may be revoked by the commissioner for neglect of duty or other just cause.

County.—Administration of roads and bridges is vested in a board of three commissioners elected for terms of two years by a majority vote of the residents of the county. The county clerk and county treasurer are, respectively, clerk and fiscal agent of the board.

The county engineer, required to possess a certificate of competency from the commissioner of highways, is appointed by the board to serve, during its term of office, as the executive official of the board in all road and bridge affairs instituted under its direction and he is required to render such reports to the commissioner of highways as may be required. The engineer has supervisory control as regards road repair and maintenance over all township supervisors appointed by the county board or township superintendents appointed by township boards.

Township.—Each county organized under the township organization plan is divided into townships, the affairs of which are administered by a board of directors composed of a township trustee, treasurer, and clerk, all elective officials. The members of this board are ex officio highway commissioners for the township, and are required to select a township superintendent as their executive official in road matters under their charge. The township clerk is required to make an annual report to the township board of directors of the work accomplished on the township system of roads, and to furnish a copy of the report to the county clerk.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 107,916 miles of public road in Oklahoma are, for the purpose of fixing responsibility for construction, control, and maintenance, divided into two groups, namely, State roads and township roads.

State roads.—These comprise between 10 and 15 per cent of the total mileage of each county selected for improvement by the county board at the joint expense of the State and county under the supervision of the commissioner of highways. These roads are selected so as to connect the county seats and the important cities of the State with roads leading to important centers in adjoining States. Initiative for construction is taken by the county board making application to the department of highways for financial aid in the construction of the road or roads specified in their application. When the project has been approved by the commissioner of highways, the laws of Oklahoma provide four forms of procedure by which State aid may be extended to the State road systems, namely:

1. By Federal and State aid combined with local funds in the ratio prescribed by the rules and regulations of the department of highways.
2. By State funds combined with local funds, the cost being borne equally.
3. By State convicts equipped for road building, loaned to the county.
4. By the proceeds of a one-fourth mill State tax combined with an equal amount of local funds.

Whenever the first or second method is followed, plans, specifications, and estimates of cost are prepared under the direction of the commissioner of highways. The letting of contracts involving Federal or State aid, supervision of the work during progress, and final inspection and acceptance of the work when completed is vested in the commissioner of highways.

The work of construction may be let by contract and paid for with Federal or State and local funds, or State convicts may, with the consent of the State

board of public affairs, and the approval of the department of highways, be furnished to county boards on their request and at their expense as regards extra expense due to the guarding of convicts while away from the State institution. The necessary tools, machinery, etc., required to equip these convict camps are furnished by the State.

Roads of this group may be constructed by the counties with State funds provided by the one-fourth mill tax levy and an equal amount of county funds, provided that plans and specifications approved by the department of highways are followed in this work.

Completed roads of this group are maintained by county boards at county expense subject to the inspection and instructions of the department of highways.

Township roads.—These are constructed and maintained by township boards with township funds under the general supervisory administration of the county engineer. All roads and bridges of this group constructed with the proceeds of township bond issues and all bridges on township roads of more than 20-foot span are required to be constructed in accordance with plans and specifications approved by the department of highways.

The township roads when constructed in accordance with plans and specifications approved by the State highway department may, when the State road system now authorized shall have been completed, be added to the State system by favorable action of the county board and the department of highways.

REVENUES.

State.—Funds are provided by a State-wide tax and by special appropriations by the legislature. The funds available for the year July 1, 1917, to June 30, 1918, and the purposes for which they may be used, are shown as follows:

1. An appropriation by the legislature of $20,000 for the support of the department of highways. Additional employees may be engaged and the State reimbursed by the counties benefiting from their services.

2. An appropriation by the legislature of $345,417 to meet Federal aid funds allotted to the State for the period ending June 30, 1918. This fund may be expended under the supervision of the department of highways with the approval of the United States Secretary of Agriculture on roads selected by the State department of highways.

3. An appropriation of $1,000,000 per annum, or as much thereof as may be available, is provided for the years ending 1918 and 1919, to be allotted to the various counties of the State for aid on State roads. One-half of this appropriation is allotted in the ratio of which the area of each county bears to the total area of the State, and one-half of the appropriation is allotted in the ratio which the population of each county bears to the total population of the State, the allotments being conditioned, however, on the county providing an equal amount.

4. An appropriation of $100,000 for the equipment of convict camps for road work.

5. A State-wide tax levy of one-fourth mill is returned in the ratio in which collected to each county providing a similar amount, provided that the combined sum be expended on State roads in accordance with the instructions of the department of highways. For the year ending June 30, 1918, it is estimated that $300,000 will be produced by this tax.

Thus the legislature provided a total of $1,765,417 for the fiscal year ending June 30, 1918.

County.—In addition to the one-fourth mill tax levy to meet the State tax levy funds, the county board may impose a general county tax at a rate not exceeding a total of 7¾ mills for county purposes and apply to the road and bridge fund any or all surplus moneys produced by this tax.

Ninety per cent of the motor-vehicle revenues, amounting to $768,300, is returned by the State to the counties in which they originated and is credited to the dragging fund for State and local roads. Any surplus in this fund may be applied to new construction.

A gross production tax is levied on certain products of the State and the proceeds thereof are returned to the counties in which they originate and are used for road and bridge purposes.

Township.—Every male person, able-bodied and not legally exempt, between the ages of 21 and 50, is required to render four days' labor each year on the public roads or to pay $5 in cash. A tax not exceeding 2 mills may be levied by the township board, the proceeds thereof to be expended for dragging the roads of the township.

BONDS.

Sinking-fund bonds in an amount not exceeding 5 per cent of the total assessed valuation of the county, bearing interest at a rate not exceeding 5 per cent per annum with terms not less than 5 years nor more than 25 years, may be issued by county boards for road and bridge purposes when authorized to do so by three-fifths of the voters of the county.

Sinking-fund or serial bonds in an amount not exceeding 5 per cent of the total assessed valuation of the township, bearing interest at a rate not exceeding 6 per cent, with terms not exceeding 25 years, may be issued by or on behalf of a township whenever three-fifths of the voters of the township so authorize.

At the close of the year 1913 there was a total of county and township road and bridge bonds outstanding amounting to $1,440,000.

OREGON.

DEVELOPMENT.

State participation in highway improvement in Oregon is of recent origin, consists of money aid applied to a system of State highways, and to post roads constructed under State supervision at the joint expense of the Federal Government, State, and counties, and is financed with the proceeds of a one-fourth mill State-wide tax and by bond issues.

The State highway commission, established in 1913, was reorganized in 1917 and given jurisdiction over the expenditure of Federal funds allotted to the State and to all construction to which the State contributed 25 per cent of the total cost.

Of the total road mileage, 10.4 per cent, or 4,875 miles, had been surfaced at the close of the year 1916. Of this improved mileage 413 miles had been constructed under the State-aid plan.

The expenditures during 1916 comprised $165,662 of State funds and $290,000 of local funds, expended by or under the supervision of the State highway department, and $5,500,000 of local funds expended under local supervision. The State thus contributed 2.8 per cent and supervised the expenditure of 7.7 per cent of the total.

During 1917 there was expended a total of $5,700,000 by all forces for highway purposes.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the diagram.

State.—At the head of the State road work is the State highway commission composed of three members appointed by the governor for terms of three years, the term of one member expiring annually. The highway commission appoints a State highway engineer, who is required to be a competent civil engineer with experience in road construction and maintenance. He holds office at the pleasure of the commission, but for a period not to exceed four years without reappointment. The commission employs such clerks, officers, and assistants to the engineer at such salaries and for such terms as may appear necessary, provided, however, that the total cost of any one year shall not exceed 10 per cent of the total fund available to the commission for that year for its work. The State highway engineer is the chief executive of the department and has general supervision of all construction and maintenance of State highways, and of other roads to which Federal or specified amounts of State funds are contributed. He also acts in an advisory capacity in highway matters in the counties when so requested.

County.—Road and bridge affairs in the county are administered by a county court composed of a county judge and two commissioners, each elected for terms of four years. The court is required to divide the county into suitable districts and appoint for each district for a term of one year a road supervisor.

The county board may appoint for a term of one year a road-master who is required to devote his entire time to supervision of the road and bridge work of the county.

Two or more counties may create, join in, and constitute a road-building district for the purpose of locating and constructing public highways within the boundaries of such district. In such cases the combined county boards constitute the governing board of the districts. The proceedings of the board thus constituted are ratified by each board independently.

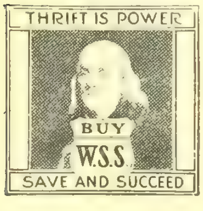
CLASSIFICATION, CONTROL, AND PROCEDURE.

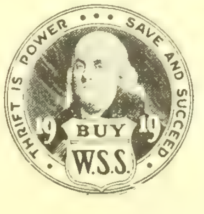
The 47,000 miles of public road in Oregon are divided for the purpose of fixing responsibility for construction, control, and maintenance into five groups, namely, State highways, hard-surfaced highways, post roads, forest roads, and county roads.

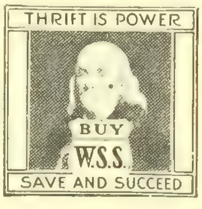
State highways.—These comprise approximately 3,800 miles of highways, selected by the State highway commission for improvement under State supervision at State and local expense. Federal funds may also be used for the construction of this system.

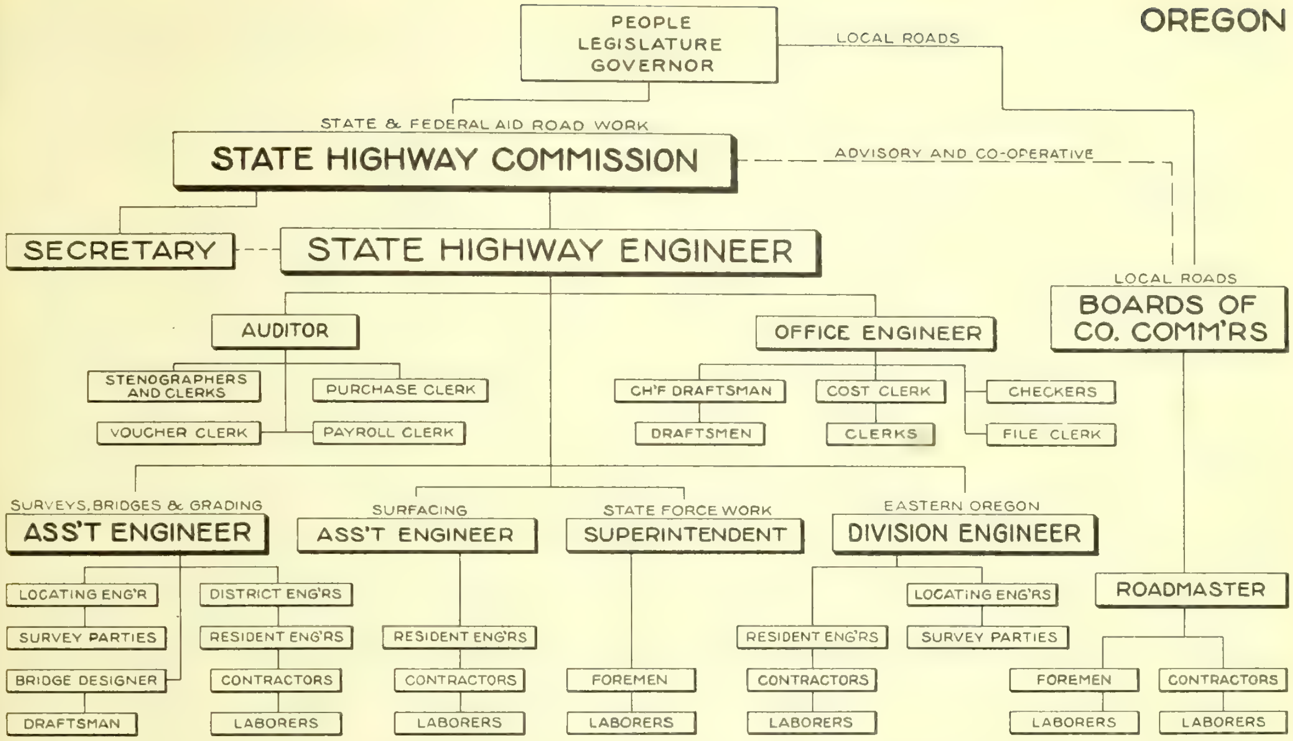
Initiative for construction of these roads is taken by the State highway commission, which enters into agreements with the interested county board as to the type of construction and the portion of cost to be borne locally. Construction is carried out under State control and supervision. Maintenance is executed by the county under State supervision, the cost therefor being shared equally.

Hard-surfaced highways.—These comprise a system of roads with a mileage of 483 designated by









the State legislature for improvement under State supervision at State and local expense and 522 miles which may be improved under similar terms. The local board having jurisdiction over the territory in which the road is located is required to prepare the roadbed and the State is required to provide the pavement. Maintenance is executed under State supervision in accordance with the terms of an agreement as to subdivision of cost entered into by the State highway commission and the county board concerned.

Post roads.—These comprise 1,380 miles of road selected by the legislature for improvement by the State highway department with Federal and State funds. All plans, specifications, etc., are prepared by the State highway department and submitted to the United States Secretary of Agriculture for his approval. Construction is carried out under the direction of the State highway department. Maintenance is executed in a manner similar to that described under hard-surfaced highways.

Forest roads.—These comprise 521 miles of road selected by the legislature for improvement in the same general manner as for post roads. These roads are located in or adjacent to national forest reservations. Maintenance is to be carried out under the supervision of the State highway department in accordance with the terms of the Federal aid act.

The State highway commission has the power to modify and to add to the systems designated by the legislature, and it is probable that portions of the State highway system selected by the State highway commission will be coincident with portions of the systems selected by the State legislature.

All work to which the State or Federal Government contributes 25 per cent or more of the total cost is under the administration of the State highway department. The work may be carried out by convict labor with the consent of the governor, by force account under the direction of the State highway engineer, or let by contract. If the county bears a portion of the cost, the county board is required to approve the contract so let.

Monthly payments covering 85 per cent of the completed work, as evidenced by the estimate of the engineer in charge, and which bears the approval of the State highway engineer, are paid on order of the State highway commission; if the county contributes to the total cost, monthly payments cover only 75 per cent of the completed work. Final payments are made in a similar manner.

County roads.—These comprise all other public roads of the State. They are opened, controlled, constructed, and maintained by county officials.

REVENUES.

State.—The State highway fund composed of the proceeds of a one-fourth-mill tax, was estimated to amount to $230,000 for the year 1917. This fund

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is available for the support of the State highway department and for payment of the State's portion of the cost of the construction and maintenance of the State highway system.

State bonds to the amount of $1,819,280.55 may be issued as needed by the State board of control to provide funds to meet Federal aid allotted for construction of post and forest roads.

State bonds to the amount of $6,000,000 may be issued by the State highway commission to provide funds to defray the State's portion of the cost of constructing the system of hard-surfaced highways. The law provided that not more than $1,000,000 of bonds of this series could be issued in 1917 and not more than $2,000,000 of this series in 1918. The issue of bonds of this series was postponed indefinitely as a war measure.

The net revenues, $150,000 for 1917, accruing from the registration of motor vehicles and the fines and penalties accruing from the violation of the motor-vehicle law are used for the payment of interest on the bonded indebtedness incurred for road purposes. The remainder, if any, may be used by the State highway commission for highway purposes.

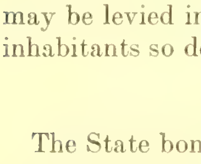
County.—County boards may levy a tax at a rate not exceeding 10 mills on each dollar of valuation. Three-fourths of the proceeds of this tax are expended in the district in which raised. The remaining one-fourth may be expended at the discretion of the county board. Special taxes at similar rates may be levied in the districts if the majority of the inhabitants so desire.

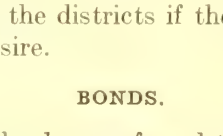
BONDS.

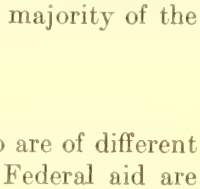
The State bonds above referred to are of different types. The bonds issued to meet Federal aid are limited to 20-year terms and bear interest at a rate not exceeding 4 per cent. The type of bond and manner of payment are fixed by the State board of control.

The State bonds to be issued for hard-surfaced highways are to be of the deferred serial type, bearing interest at 4 per cent, and may run not to exceed 20 years after 6 years from the date of issue.

Sinking-fund bonds in an amount not exceeding 2 per cent of the assessed valuation of the county may be issued by the county court when authorized by a majority of the voters of the county. The term of such bonds is stated in the proposal submitted to the voters. The interest on such bonds may not exceed 6 per cent. On January 1, 1915, there was outstanding $1,615,000 of county bonds issued for terms varying from 10 to 30 years, with interest at 5 and 6 per cent.







PENNSYLVANIA.

DEVELOPMENT.

State participation in road construction, improvement, and maintenance in Pennsylvania is of Statewide scope, was first evidenced in 1903, consists of actual construction and maintenance of a system of State roads with State funds, allotment of money aid to local roads of importance, and supervision of and allotments of money aid to the roads administered by townships of the second class, and is administered by a State highway department.

Road improvement in Pennsylvania had its beginning in private toll roads, which from their first establishment in 1792 were gradually extended throughout the State. However, as the railroads became the principal means of long-distance transportation, the toll roads were allowed to deteriorate, and many were abandoned or condemned and taken over by the local authorities as public roads. At present only a small mileage of the original system is administered by private ownership, and this mileage is decreased each year by purchase by the State.

Prior to 1895 road supervision and construction was executed by the township boards, but as this form of management did not prove satisfactory the county administration of roads was authorized by the legislature during that year. While county control was a step in the direction of centralized control of road matters, it was not until 1903 that the State highway department was organized, with the necessary funds to assist the counties in their road affairs.

From its beginning in 1903 the highway department has been modified from time to time until it, as now organized, has full control over the system of State roads comprising 11 per cent of the entire mileage of the State; supervisory control over the road system of the second-class townships which comprise about 85 per cent of the total mileage of the State, and extends money aid to counties, boroughs, or townships for the improvement of local roads which are of importance. Local roads improved with State aid comprise about 1 per cent of the total mileage of the State.

Approximately 11½ per cent of the road mileage of the State has been improved with funds supplied by State and local organizations. During the year 1916, $2,958,455.51 was expended by the State for maintenance of State roads and bridges.

The influence in the road and bridge work of the State exercised by the State highway department is evidenced by its control over the funds expended. During 1916 the State highway department expended $3,663,352 of State funds and $322,040 of local funds, and in addition thereto distributed to townships of the second class $712,501 of State funds. The total road and bridge expenditures within the State by both State and local forces for the period reached $10,985,392. Thus the State exercised supervision over the expenditure of about 43 per cent of all road expenditures.

During 1917 there was expended by all forces a total of $11,463,000 for highway purposes.

ORGANIZATION.

The organization of the State and local road forces and the relation existing between them is shown on the diagram herewith.

State.—The executive official of the State highway department is the State highway commissioner appointed by the governor for a term of four years. He provides rules and regulations governing the business of the department, appoints engineers, clerks, and such other employees as may be required, and prescribes their duties. He is assisted in the executive work of the department by a first deputy commissioner, a second deputy commissioner, a chief engineer, and an auditor, all of whom are appointed by the governor.

The department is divided for administrative purposes into five general divisions with specific powers and duties, namely:

1. The bureau of township highways is administered by the first deputy commissioner, who has general supervision of all road construction and maintenance administered by the local boards of townships of the second class.

A district engineer and such other assistants as may be needed is in charge of each of the five districts into which the State has been divided. He reports to the first deputy and represents him in carrying out the duties of the bureau, which in general are to prescribe and enforce rules and regulations not in conflict with State laws, fixing the duties of highway officials in townships of the second class; to approve all contracts let by such township officials for equipment, bridges, etc.; to supervise all townships of the second class road and bridge construction and maintenance, and to make an annual report to the commissioner of work accomplished and such statistics relative to roads and bridges of the State as may be at hand.

2. The division of maintenance is administered by the second deputy who allots funds available for maintenance and repair of State and State-aid roads. The allotment is made on recommendation of the assistant engineers of the division of construction who are in charge of the various districts into which the State has been divided for construction and maintenance purposes. The maintenance division employs as many as 10,000 or 12,000 men during the working season.

3. The division of construction is administered by the chief engineer who has charge of construction and maintenance of State and State-aid roads, and who is assisted by a central office force and a field force which for administrative convenience is divided into 15 district organizations, headed by district engineers, with such additional forces as may be needed from time to time.

4. The division of audits is administered by the auditor who examines all accounts against the department, and issues warrants for all payments made by the department.

5. The clerical and registration division is administered by the chief clerk, appointed by the commissioner, who has charge of the registration of motor vehicles, collection of fees therefor, and keeps records of all accounts and expenditures of the department. A comprehensive and effective cost-keeping system covering all expenditures of the department is administered by this division.

A statistician, appointed by and reporting directly to the commissioner, is in charge of the collection of data and information pertaining to the roads of the State. He edits bulletins and publications relative to the duties and accomplishments of the department.

County.—Authority over road affairs in the county is vested in a board of three commissioners elected for a term of four years. The county surveyor, an elective official, may be designated by the board, or the board may employ a county engineer to take charge of the road and bridge improvements under their control.

First-class townships.—Townships containing 300 or more inhabitants per square mile are designated first-class townships and are governed by a board of elective commissioners. They have full control over all township roads in their jurisdiction.

Second-class townships.—These comprise all other townships of the State. Authority over road and bridge matters is vested in a board of three elective supervisors. The board appoints a highway superintendent or road master and such other forces as may be required. Practically all operations of this board and its employees in road and bridge matters are subject to rules, regulations, and supervision of the State bureau of township highways.

CLASSIFICATION, CONTROL, AND PROCEDURE.

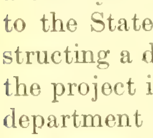
The 91,556 miles of public road in Pennsylvania are divided for the purpose of fixing responsibility for construction and maintenance into five groups, namely, State highways, State-aid highways, county roads, first-class township roads, and second-class township roads.

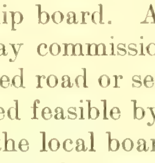
State highways.—These comprise 375 routes with a mileage of 10,235 designated in a general way by the State legislature, and are to be constructed and will be maintained by the State highway department with State funds. On January 1, 1918, approximately 2,000 miles of road of this group had been improved. Surveys, plans, specifications, and estimates are executed by the State highway department. Construction may be done by force account under the control of the department or let by contract. When by contract let by the State highway commissioner, inspection and supervision is exercised by the State highway department. Monthly payments may be made as the work progresses. They are based on an estimate prepared by the assistant engineer in charge of the work and are approved by the district engineer and State highway commissioner. Payment for 90 per cent of the amount of the estimate is made by the State treasurer on receipt of a warrant approved by the State auditor and the auditor of the State highway department.

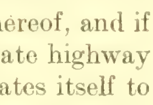
State-aid highways.—These comprise about 1,050 miles of road improved by State and local funds, of which 459 miles are maintained by local forces. The remaining mileage, 591, located on State routes is maintained by and at the expense of the State.

New construction is instituted on the initiative of a county or township board. Application is made to the State highway commissioner for aid in constructing a designated road or section thereof, and if the project is deemed feasible by the State highway department and if the local board obligates itself to pay one-half the cost of construction and maintenance. Surveys, plans, specifications, and estimates are prepared by the district engineer and are approved by the State highway department and by the local board concerned.

Contracts are let by the State highway commissioner and construction is carried out under supervision of the State highway department. Payments are made by the county treasurer on warrants approved by the State highway commissioner until local funds appropriated for the project are exhausted; the remaining payments are then made from State funds by the State treasurer in the manner outlined under State highways.







County roads.—These are selected by the boards of county commissioners subject to the approval of the grand jury and the court of quarter sessions.

First-class township roads.—These comprise all roads of the townships not included in the three preceding systems. Roads of the third and fourth groups comprise a small percentage of the total road mileage of the State. They are constructed and maintained by their respective boards with local funds. The State highway department has no jurisdiction over roads of these groups unless they are improved by means of State-aid highway procedure.

Second-class township roads.—These comprise all other public roads of the State. They are administered by township boards under supervision of the State highway department. The State law provides that townships of this class which collect their road taxes in cash are entitled to an allotment from State funds equal to 50 per cent of the taxes collected. However, the allotments may not exceed $10 per mile of road. The legislature since 1911 has failed to provide funds sufficient in amount to pay the entire amounts due the townships.

All equipment, materials, etc., used by the State or local forces on State highways, State-aid highways, and second-class townships are purchased by contract let by or under the supervision of the State highway commissioner.

REVENUES.

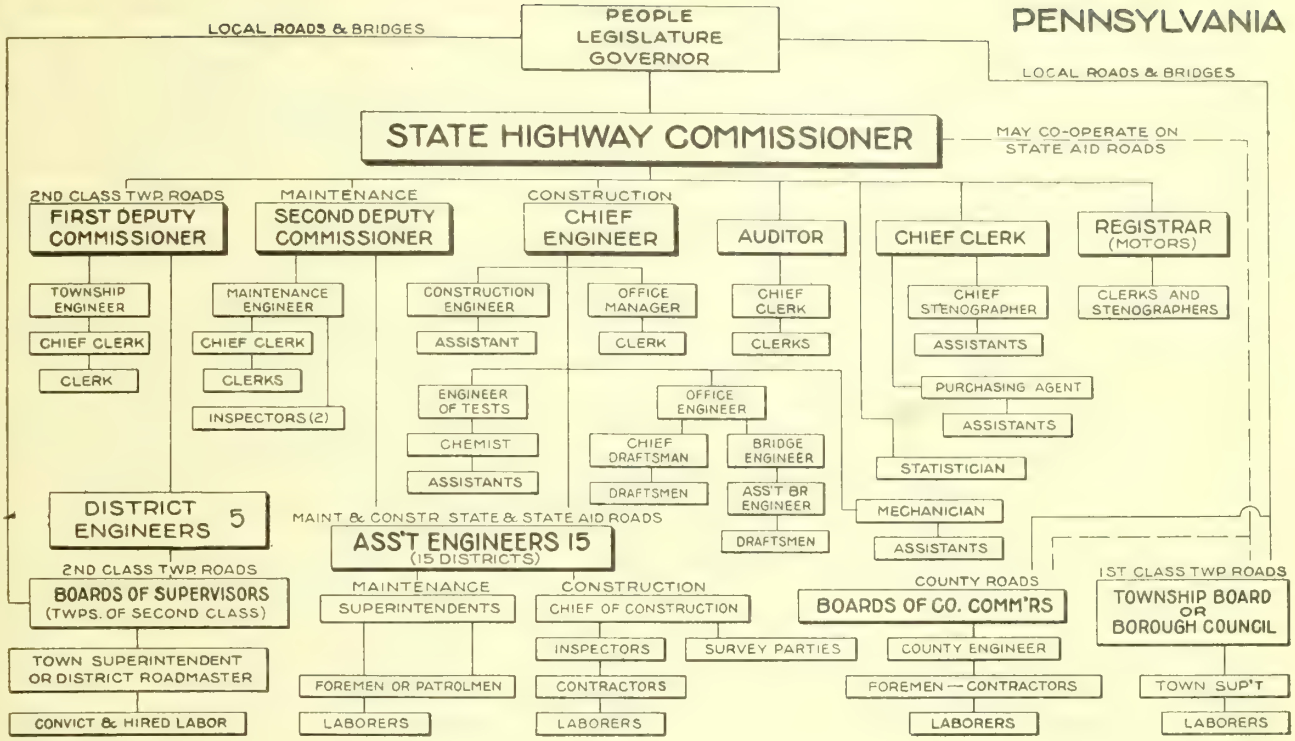
State.—For the two years June 1, 1917, to May 30, 1919, the State legislature has provided for each year the following amounts for the support of the State highway department and for State participation in road and bridge improvement.

For construction of State highways	$3,000,000
State aid to counties	750,000
Purchase of turnpikes	250,000
Cash bonus to townships of the second class	936,735
Maintenance of highway department	377,500
Total	5,314,235

In addition thereto the gross receipts of the motor-vehicle license fund, estimated at $3,268,026 per annum, are available for maintenance of State highways.

County.—The boards of county commissioners have authority to levy for road and bridge purposes an annual tax at a rate not exceeding 2 mills on each dollar of assessed valuation.

Township.—The boards of supervisors have authority to levy for road and bridge purposes an annual tax at a rate not exceeding 10 mills on each dollar of valuation, and may with the approval of the court of quarter sessions levy an additional tax at a rate not exceeding 10 mills on each dollar of valuation.



BONDS.

Bonds may be issued by counties and townships for road and bridge purposes at a rate of interest not exceeding 5 per cent and in amounts not exceeding 2 per cent of the assessed valuation of the county or township. The type and term of such bonds is not specified by law. On January 1, 1915, $27,547,659 of county and township bonds were outstanding.

RHODE ISLAND.

DEVELOPMENT.

State participation in road and bridge improvement in Rhode Island dates from 1896, is confined to a system of State roads although provision has been made for State aid to towns and is administered by a State board of public roads.

State interest in and control over road improvement began in 1896 with the appointment of a State highway commissioner, who, during the two succeeding years, constructed in several towns a total of 9½ miles of object-lesson roads. These roads consisted of half-mile sections of water-bound macadam, the cost being paid 75 per cent by the State and 25 per cent by the town. These roads served as a demonstration of the stability of roads constructed of proper materials under skilled supervision, and were no doubt useful in stimulating a demand for further road improvement. However, State interest in road improvements remained inactive until 1902, when the State board of public roads was first organized. At this time a system of State roads was designated by the State legislature for improvement with State funds.

The State road system as originally outlined has been augmented from time to time until it now comprises 37 per cent of the entire road mileage of the State. Three hundred twenty-four and five-tenths miles, or 40 per cent, of the State system has been surfaced, 207.7 miles being water-bound macadam and 116.8 miles being bituminous macadam. Thirty-four and five-tenths per cent of all roads of the State have been improved by surfacing.

The total expenditures for road and bridge purposes by all road forces of the State during 1916 reached $942,152. Fifty-seven and one-half per cent of this amount, or $543,162, was State funds expended by the State board of public roads.

During 1917 a total of $862,000 was expended by all forces in the State for highway purposes.

Since 1914, the work of the board has been confined to bridge construction, and bridge and road maintenance, funds for new road construction not being available. However, funds sufficient in amount to provide for the maintenance of the existing improvements were made available for 1917.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the diagram.

State.—Authority over road affairs is vested in the State board of public roads consisting of five members, one from each county of the State, appointed by the governor for terms of five years, one term expiring annually. The executive official of the board is the chief engineer appointed by the board for an unlimited term. He is assisted in the central office by deputies who have charge of each of three divisions, namely, bridges, surveys, designs and estimates. Such other technical assistants and clerical force as may be required are provided for the central office. The State is divided into six divisions, each in charge of a division engineer who reports to the chief engineer and represents him in the work of construction, repair, reconstruction, and maintenance in the district. A field force of inspectors, field parties, and other help is provided in sufficient amount to carry out the work.

The collection of fees for motor vehicle and chauffeur licenses is carried out under the direction of the board.

County organization.—The counties in Rhode Island, as such separate organizations, take no part in road and bridge affairs.

Towns.—The town council composed of five or seven elective officials exercises, through executive officials appointed by the council or elected by the voters, control and maintenance of local roads and bridges under their jurisdiction.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 2,170 miles of public roads of Rhode Island are divided, for the purpose of fixing responsibility for construction and maintenance, into two groups, namely, State roads and town ways.

State roads.—These comprise 800 miles of the principal roads of the State designated by the State legislature. The roads of this group are improved and maintained by the State with State funds. The State law requires that the width of surfacing on tangents shall be not less than 14 feet nor more than 18 feet. The width on curves is fixed by order of the board and is generally wider. However, the width of roadway may be increased on request of and at the expense of the towns in which located.

All surveys, plans, and specifications for roads of this group are prepared by the State board of public roads. Construction and maintenance are carried out under the direction of the board by convict labor, by force account, or by contract.

When by convict labor, the convicts are furnished by the penal and charitable commission, on request of a majority of the board. The additional expense incurred in guarding and transporting the convicts is met from the fund provided for construction and maintenance purposes. Convicts detailed to road work are entitled to special privileges and may receive a small wage for their labor.

When by force account all steps of the work are supervised and administered by employees of the board.

When by contract let by the board after due publicity to a contractor who furnishes bond in 50 per cent of the contract price, the work is under the supervision of an inspector detailed to the work by the chief engineer, and the occasional inspection of the division engineer and of the chief engineer.

Monthly payments based on estimates covering 85 per cent of the completed work are made on order of the chief engineer to the contractor by the State treasurer with the approval of the State auditor.

Final payment is made in a similar manner when the completed work has been accepted by the division engineer and by the chief engineer.

Town ways.—These comprise all other roads of the State. They are controlled, constructed, and maintained by local officials with local funds.

The State law provides that whenever a town makes an annual appropriation, by a vote of the electors, for road and bridge purposes equal in amount to an assessment of 20 cents or more on each $100 of taxable property in the town, and requests the State board of public roads to supervise the expenditure of such appropriation, such town is entitled to State aid in the sum of one-fifth of the amount appropriated. Only one town has taken advantage of this provision of law.

REVENUES.

State.—The funds for the calendar year 1917 at the disposal of the State board of public roads are obtained from several sources, namely:

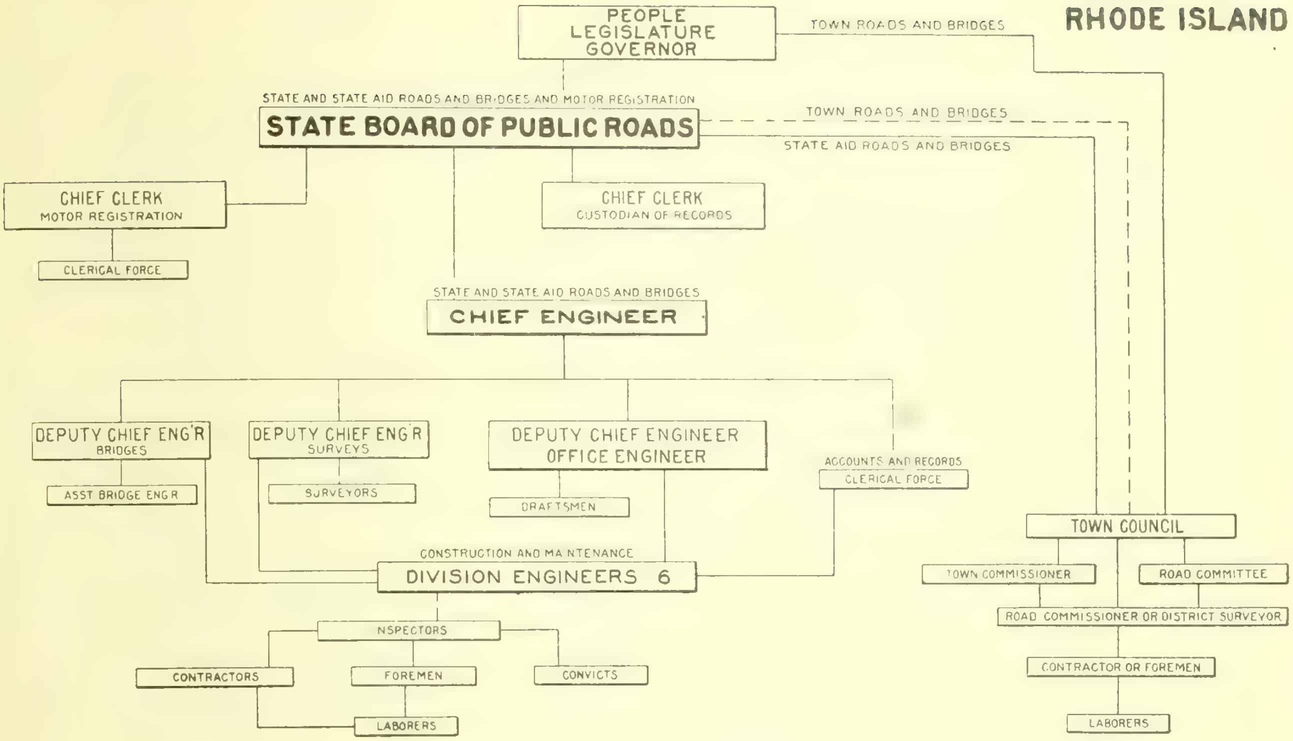
1. The fees collected from licenses of chauffeurs and motor vehicles and penalties collected for violation of the motor-vehicle law, amounting to $353,652, are available for expenditure by the State board of public roads in the following manner: A total of $2,500 is paid to members of the board as annual salary; not to exceed $12,500 for supplies for the motor-registration department; not to exceed $20,000 for clerical and contingent expense incident to enforcement of the motor-vehicle laws, and the remainder of the fund, $318,652, for the repair and maintenance of State roads.

2. By legislative appropriation of $2,500 for salaries of board, $5,000 for traveling expenses of board and for salaries and expenses of employees of the department, $175,000 for bridges on the State roads, and $34,997 to meet funds allotted by the United States Government.

3. The proceeds amounting to $224,423 of a State-wide tax of three-tenths of a mill levied on all taxable property in the State.

4. The refunds estimated to be $2,450 from towns and public-service corporations to the bridge construction fund.

Thus the total State funds available amounted to $798,022 exclusive of refunds.



Local.—Town funds are raised by local taxes. The amount of the fund for road and bridge purposes is fixed by a vote at the annual town meeting and the tax rates are fixed accordingly by the administrative officials of the town.

BONDS.

Town bonds may be issued for road improvement when specially authorized by the legislature, but apparently none have been issued.

State bonds may be issued on authority of the legislature. Such bonds may bear not to exceed 4 per cent interest and to be retired by the sinking fund method within 50 years. The total State bonds outstanding on January 1, 1918, amounted to $1,975,000. These bonds must be retired in 30 years and bear interest varying from 3 to 4 per cent.

SOUTH CAROLINA.

DEVELOPMENT.

State participation in road building is limited to educational, advisory, and supervisory assistance administered by a State highway commission established in 1917. No money aid is extended by the State, but 20 per cent of the automobile-registration fees is used for the support of the State highway department, while 80 per cent of such fees is refunded to the counties. The State exercises no control over the expenditure of these funds except on request of local authorities. For a number of years previous to 1917 the department of agriculture, commerce, and industries collected and disseminated information and statistics on road building, and issued road maps and route books.

During 1917 expenditures by all forces of the State for road purposes totaled $1,277,000.

ORGANIZATION.

The organization of the State highway department and its relation to the local road forces is shown on the diagram.

State.—The State highway commission is composed of two nonsalaried members appointed by the governor and three ex officio members as follows: The senior professors of civil engineering of the Military College of South Carolina, of the Clemson Agricultural College, and of the University of South Carolina.

A highway engineer appointed for an unlimited term by the commission, which appointment may be based upon an examination, must be skilled and experienced in the design, construction, and maintenance of roads and bridges. Upon the recommendation of the State highway commission the State highway engineer appoints two assistant engineers, which appointments may be based upon a civil-service examination. A clerk, who serves as secretary to the commission, is appointed by the commission.

The highway department is composed of two divisions, viz, engineering and automobile licensing and registration. The engineering division, administered by two assistants under the State highway engineer, has charge of the work, requested by local authorities of making surveys, preparing plans, specifications, and estimates, and the supervision of road and bridge work on Federal-aid projects. The registration and licensing of automobiles is administered by a clerk who is secretary to the commission, and who reports to the State highway engineer.

County.—Except where special laws apply, the control over roads and bridges in the several counties is vested in a county board of commissioners composed of the county supervisor as chairman, elected by the people for a four-year term, and two commissioners appointed by the governor on the recommendation of the county delegation to the general assembly. Some counties have more than two commissioners and several counties operate under special laws. District overseers have immediate control over the roads in the various townships. These are appointed by the county board, or subject to its approval, or by the township board of commissioners in counties where such boards exist.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The roads of South Carolina, comprising about 32,000 miles, are, for the purpose of fixing responsibility for construction, control, and maintenance, divided into two groups, viz: Proposed State highway system and county roads.

Proposed State highway system: In order to comply with the requirements of the Federal-aid road act, the State highway department has designated a tentative State highway system which it is proposed to improve with Federal aid and county funds during the five-year period 1917 to 1921. This system includes 2,550 miles, or 6.5 per cent of the total road mileage of the State, and connects the county seats and principal market centers. When local authorities request Federal aid, plans, specifications, and estimates will be prepared by and at the cost of the State. The work will be done by the counties by contract, force acccount, or prison labor, and under the inspection and supervision of the State highway department. When completed the roads will be maintained by the counties under State supervision. The cost of construction will be borne 50 per cent by the counties and 50 per cent by the Federal-aid fund. The counties will pay the entire cost of maintenance.

County roads.—All roads in the State including the proposed State system are county roads, built and maintained under the direction of county authorities with county and township funds. However, surveys, plans, specifications, and estimates may be prepared and construction and maintenance may be supervised by the State highway department on request of the local authorities.

REVENUES.

State.—Automobile license fees are collected by the State highway department. Of the amount collected, 20 per cent is retained to pay the expenses of collection and for the support of the State highway department, and 80 per cent is returned to the counties from which collected for the construction of roads and bridges therein. No supervision over the refunds to counties is provided for except on request of county authorities. During 1917 there was collected $113,556, of which $88,630 was refunded to the counties and $24,926 was retained by the State.

County.—Boards may annually levy a 1-mill tax, the proceeds to constitute a part of the county-road fund. They may also levy a similar tax on property in any township on written request of two-thirds of the property owners of the township. An additional levy of 2 mills may be assessed for two-year terms by the county board on any township if agreed to by a majority vote of the electors who own real and personal property subject to taxation. One-half of the taxes derived from the sale or manufacture of timber is used for the improvement of public roads.

Unless by law exempt, all male persons between certain ages, varying from 18 and 21 to 50 and 55, are required to work from 2 to 12 days on the public roads, or to commute the same in cash at the rate of from $1 to $3 per day. The conditions under which statute labor is applied vary under the special laws applying to the various counties.

It is estimated that the various counties and townships expended about $1,250,000 for road and bridge purposes during 1916.

BONDS.

There is no general law authorizing the issuance of road and bridge bonds. Such bonds when authorized are by special acts of the legislature. It is estimated that $460,000 of county and township bonds were outstanding on January 1, 1915. Since that date approximately $1,675,000 county and township bonds have been authorized and sold.

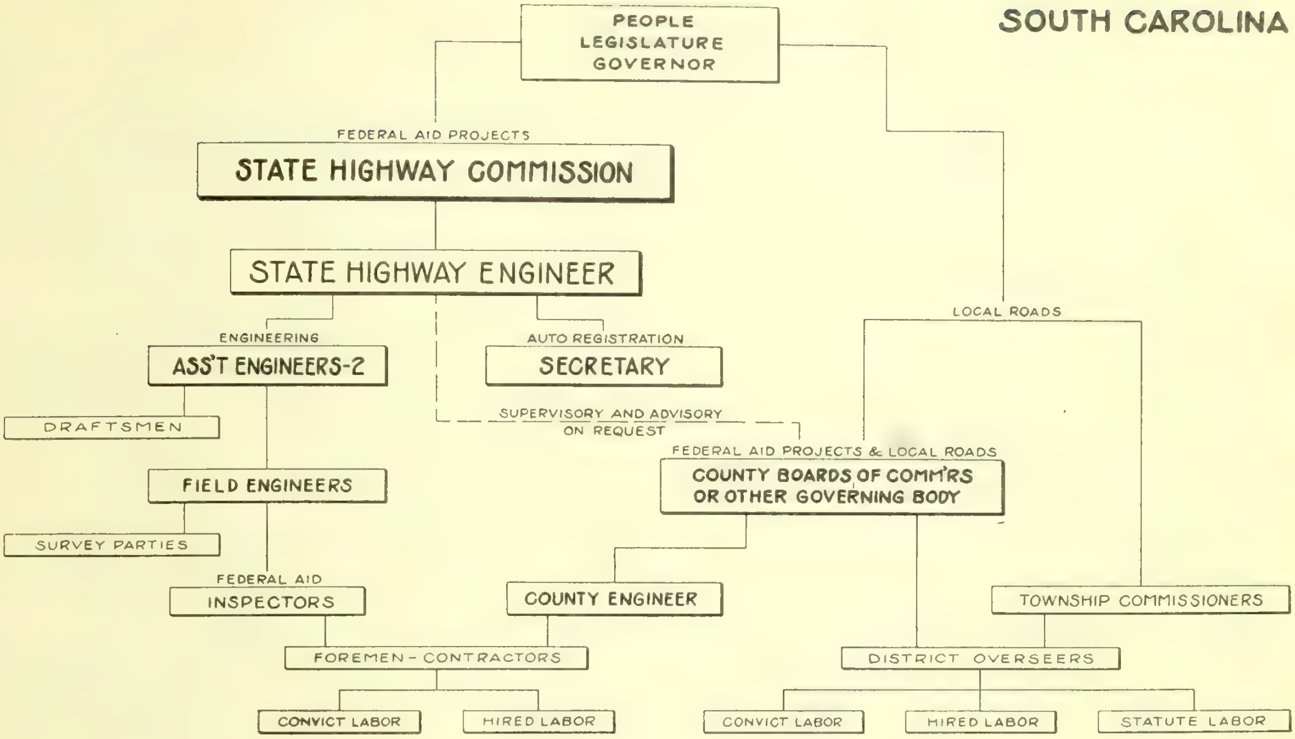
SOUTH DAKOTA.

DEVELOPMENT.

State participation in road work in South Dakota is of recent origin, of limited amount, is dependent on local initiative, is financed by the proceeds of a State-wide tax, and is administered by a State highway department.

State interest in road improvement in South Dakota dates from the passage in 1913 of an act

SOUTH CAROLINA



creating a State highway commission with supervisory and advisory duties and the designation of a system of State highways to be constructed under State supervision at county expense.

Road improvement in this State is confined principally to the construction of bridges and culverts, and the grading of earth roads. During the years 1915 and 1916 the expenditures by local forces for bridge and culvert work exceeded the sum expended for road work.

On January 1, 1917, 750 miles, or 0.8 per cent, of the total road mileage were reported as surfaced, while on January 1, 1918, 1,500 miles, or 1.5 per cent, of the total mileage had been graded and drained.

Expenditures by local forces during the year 1916 reached $1,250,000. No State funds were expended other than for the support of the State highway commission, which was engaged in educational and advisory duties.

Centralized control over road work is now becoming established in accordance with the terms of the legislation enacted in 1917, and road and bridge improvement will proceed in accordance with standard plans and will be maintained when completed under State supervision.

Total expenditures during 1917 by all road forces reached $2,755,000.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the diagram.

State.—The State highway department is composed of the governor as chairman, the State engineer as secretary, both ex officio members, and a third member appointed by the governor. The appointive member is required to be an experienced road builder having the qualifications of a civil engineer. Such other assistants and clerical force as may be necessary are employed by the department.

The department so constituted supervises, controls, and directs the building of roads and bridges to which Federal or State aid is contributed and controls to a limited extent the construction or repair of local roads. Action in such local cases is not taken by the department until complaint has been filed against the local officials by five freeholders of the county in which the work is in progress. The department is required whenever a county employs a competent road builder for the purpose of supervising or controlling road building to authorize him to plan, supervise, and control the road building in said county.

County.—The road and bridge affairs are administered by a board composed of three or five commissioners elected for terms of four years. The county auditor and the county treasurer are respectively clerk and fiscal agent of the board.

Counties not organized into townships are divided by the board into districts and a road supervisor is appointed for each district. The county board may employ a suitable person to take charge of the county road work, and he may be designated the county engineer.

Township.—Road and bridge affairs in legally organized townships are administered by a board of three supervisors elected for terms of three years, one being elected each year. This board has jurisdiction over township roads which are generally the least important roads of the county. The township board may not expend to exceed $125 on a bridge or culvert without first securing authorization from the county board. Such road forces as may be required for township work are employed by the township board.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 96,306 miles of public road of South Dakota are divided for the purpose of fixing responsibility for control, construction, and maintenance into three groups, namely, State roads, county roads, and township roads.

State roads.—These comprise approximately 6,000 miles of public road selected by the county boards with the approval of the State highway department for improvement under the supervision of of the department with Federal or State and local funds. Initiative for construction is taken by the county board. On approval of the project by the department and the designation of the amount to be contributed by the county, surveys, plans, specifications, and estimates are prepared at the expense of the county and submitted to the State highway department for approval. Bids are requested by the State highway department and the contracts may be let or the work may be done by force account under the direction of the department. Partial and final payments are made on order of the State highway department. The county's portion of the cost is paid by the county board when ordered to do so by the State highway department. Improved roads of this group are maintained by county forces at county expense, subject to the supervision and inspection of the State highway department.

County roads.—In counties not organized into townships all roads other than State roads and the more important roads in organized townships are classed as county roads. They are improved and maintained by county forces at county expense. The State highway department exercises no supervision over these roads unless requested to do so by five or more freeholders of the county. All bridges constructed on these roads are required to be built in accordance with plans provided by the State engineer, or a competent assistant designated by him.

Township roads.—These comprise the minor roads of organized townships. They are opened, constructed, and maintained at township expense by township officials subject to limitations fixed by statute.

REVENUES.

State.—Revenues for road and bridge purposes are obtained from a tax levied at a rate not exceeding one-tenth of a mill. From the proceeds of this tax the legislature appropriated $100,000 for the fiscal year ending June 30, 1918, and $120,000 for the fiscal year ending June 30, 1919. These amounts are available for payment of the salaries and expenses of the State highway department and for the construction of State roads. Eighty per cent of this fund must be expended in the counties in which collected if application therefor is made by the county board within one year from the date of the tax levy.

County.—Eighty-five per cent of the motor vehicle license fees originating in each county are retained in the county motor vehicle road fund, and are used for gravelling and dragging the public roads outside the limits of cities. The county board may levy a 2-mill tax, and when authorized by a majority of the electors this tax may be increased to 5 mills for road and bridge purposes. A poll tax at a rate of $1.50 is levied on all male persons between the ages of 21 and 50. This tax may be paid in cash or a day's labor may be contributed in lieu thereof.

Township.—The electors of each township may at the annual town meeting in March appropriate such sums as they deem proper for road and bridge purposes and fix the tax rates to produce these amounts. However, the road tax may not exceed 50 cents on each $100 of assessed valuation.

BONDS.

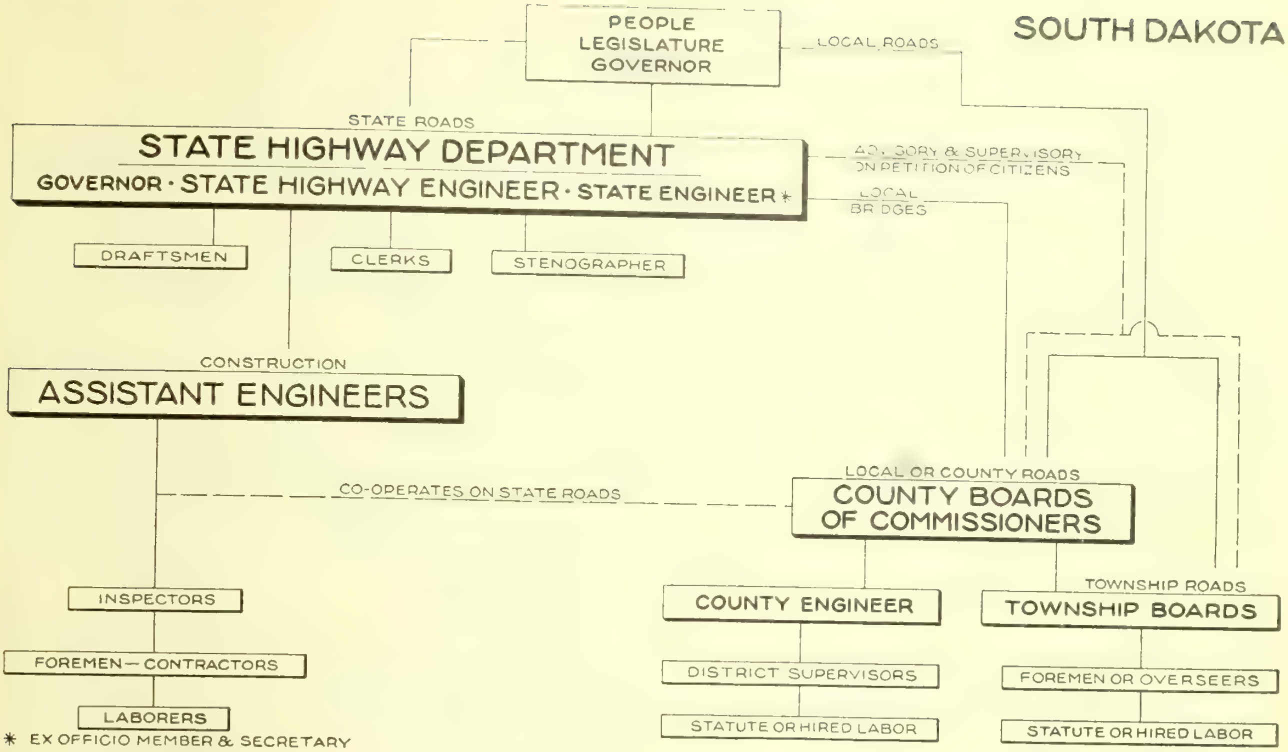
Sinking-fund bonds may be issued by county boards in amounts not exceeding 5 per cent of the total assessed valuation when authorized by three-fourths of the electors of the county. Such bonds if issued shall become due in not less than 5 nor more than 20 years from the date of issue, and they may bear interest at rates not exceeding 5 per cent.

Bonds may be issued by township boards in an amount not exceeding 5 per cent of the total assessed valuation of the township, and in no case to exceed $5,000. Such bonds may bear interest at a rate not exceeding 10 per cent, and may not run more than 20 years. No State, county, or township bonds are outstanding in South Dakota.

TENNESSEE.

DEVELOPMENT.

State participation in road and bridge improvement in Tennessee is of very recent origin, but is of State-wide extent. The State highway commission, organized in 1915, has supervision of construction and maintenance of the State highway system, com-



prising about 5 per cent of the total road mileage of the State. Little improvement has been done under the direction of the State highway commission, due to its recent organization and to the limited amount of funds placed at its disposal by the State legislature. However, during 1916, $200,000 of State funds and $400,000 of local funds were expended under the direction of the commission on the State highway system for maintenance, which, in many cases, amounted practically to reconstruction.

Beginning with 1917, a State-wide tax was levied on all assessable property in the State, and the proceeds thereof, together with Federal funds and auto-license revenues, constitute the fund at the disposal of the commission for construction and maintenance of the State highway system.

About 20 per cent of the road mileage of the State has been hard-surfaced, and a larger percentage of the mileage has been graded and drained by and at the expense of the various counties of the State. During 1916 about $4,000,000 was expended by the counties for road and bridge purposes. The State highway commission exercises control over projects involving the expenditure, either wholly or in part, of State funds and may advise county officials under certain circumstances relative to the expenditure of local funds.

The total expenditure during 1917 by all road forces reached $2,481,000.

The Legislature of Tennessee has provided many road laws applicable to the counties possessing certain qualifications, with the result that neither uniform organization nor methods of construction and repair are found in the various counties of the State. The State highway commission is engaged in the dissemination of information throughout the State relative to efficient methods of construction and repair by local officials, and improvement in the general condition of the roads of the State is to be expected.

The State is divided into three general divisions, namely, eastern, middle, and western Tennessee, which differ greatly in soil, topography, and amount and distribution of road-building materials. Therefore, the types of construction vary to a marked degree in the various localities, due to the availability and cost of road-building material.

ORGANIZATION.

The organization of the road forces of the State and their relation is shown on the diagram.

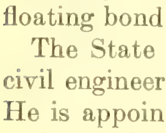
State.—The State highway commission is composed of six members, three ex officio, namely, the governor of the State, the State geologist, and the dean of engineering of the University of Tennessee, and three members appointed by the governor for terms of six years each, resident, respectively, in eastern, middle, and western Tennessee. No more than two of these appointees may be of the same political faith. The commission elects one of its members as chairman for a term of two years, and appoints a secretary for a like term. The secretary is required to be qualified in road building and maintenance.

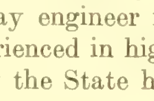
The commission is required to hold such meetings as may be necessary for the conduct of the business of the commission; to prepare a highway plan of the State showing the system of intercounty highways comprising the system of State highways; to establish standards for the construction and maintenance of highways in the various counties; to designate in each county the number of miles of traveled road which are deemed of sufficient importance to be classified as main traveled roads, and which may be entitled to State or Federal aid for their improvement (additional roads may be added to this system by the commission); to publish at stated periods such information and statistics as may have been compiled relative to the roads and bridges of the State; to advise county or district road officials in road and bridge matters brought to their attention; and to request information from such officials relative to the roads and bridges of their respective districts. The commission is also required to keep on file and furnish when requested by county or district road officials current prices of bridges, culverts, road materials, tools, implements, or machinery.

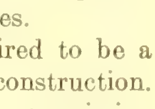
All licenses for motor vehicles are issued and the fees therefor are collected by the State highway commission.

The secretary is the executive and administrative head of the commission and is in charge of the office of the commission at Nashville, and his approval is required to all contracts and to all checks, vouchers, or warrants drawn against funds under the control of the highway commission. He is further required to assist county and district authorities in making the necessary financial arrangements for raising and floating bond issues for highway purposes.

The State highway engineer is required to be a civil engineer, experienced in highway construction. He is appointed by the State highway commission and may be removed for due cause. Such other engineering or other expert assistants employed by the commission are required before entering upon their duties, to pass a satisfactory examination conducted by a committee composed of the dean of engineering of the University of Tennessee, the State geologist, and the State highway engineer. The State highway engineer is in charge of all work where State or Federal funds are involved, and he is required to approve all vouchers, claims, and accounts paid out of the State highway fund or any joint fund where the work is financed in part by county or district and State funds. He may be requested by county officials to take charge of work financed wholly by county funds. He is the technical advisor of the State highway commission and is required to furnish advice to county officials on matters pertaining to the surveys, construction, and maintenance of roads and bridges when requested.







County organization.—The governing board of the county is known as the county court and is composed of the county judge, and two justices of the peace from each district of the county. The presiding officer, the county judge, of this court may be chosen from the members of the court, but in many counties he is elected by the people at the general biennial election. This court, known as quarterly court, is composed of the presiding officer and the justices, and meets in January, April, July, and October. The chairman, who constitutes another division of the court, is required to hold sessions at the first of each month, unless otherwise provided by legislation, applicable to counties possessing certain qualifications.

The quarterly court at its January term in odd years divides the county into road districts, and elects a road commissioner for each district for a term of two years. Such commissioners are the executive officers of the court in all road matters in their respective districts, and they may appoint overseers for sections of the road containing not less than 1 nor more than 5 miles. Certain counties of the State favored by legislation have a road commissioner or a board of road commissioners elected for terms varying between two and six years, depending upon the county and the legislation applicable. Certain counties are authorized to employ engineers skilled in road building. Due to the large amount of special legislation in force in Tennessee, no uniform organization can be laid down as applicable to all counties of the State.

CLASSIFICATION, CONTROL, AND PROCEDURE.

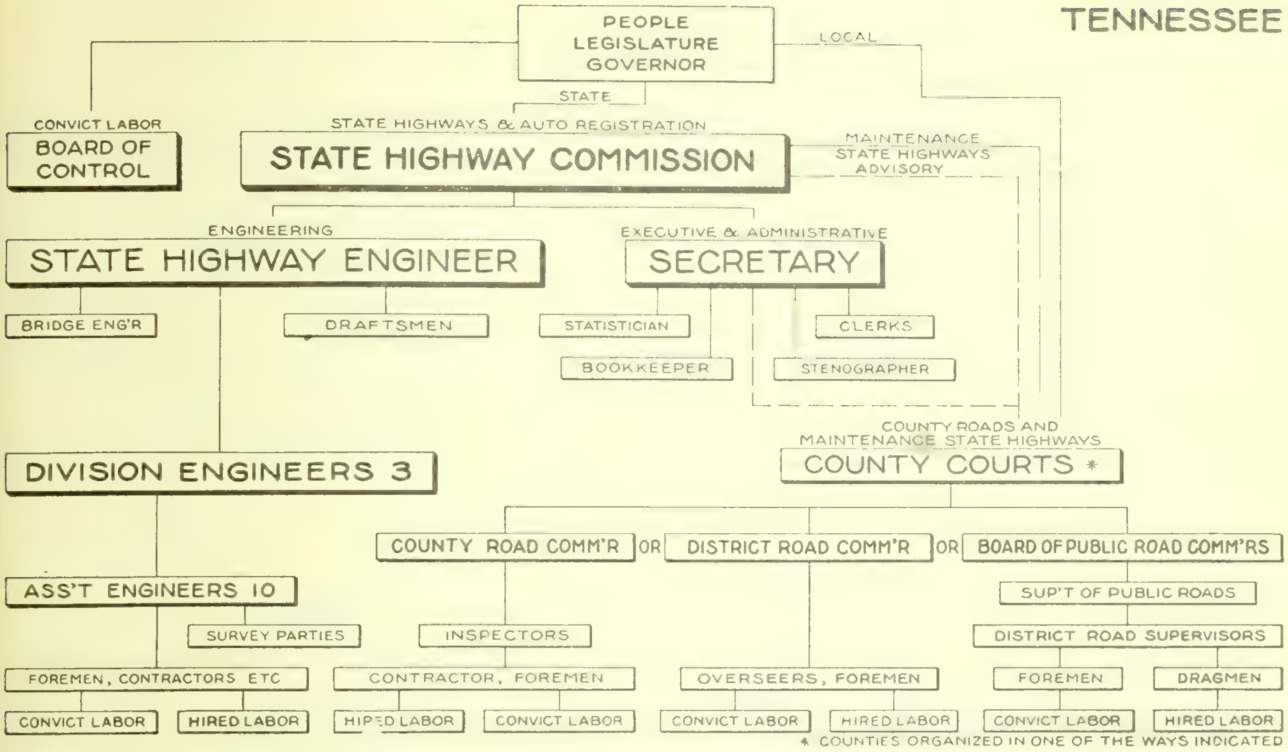
The roads of Tennessee are divided into three general classes:

State highway system.—These comprise the roads selected by the State highway commission as of sufficient importance to warrant the expenditure of State and Federal funds to improve and maintain them. Portions of the State highways may be improved under the State-aid plan, the State and counties providing a joint fund for their construction. In such cases, the State provides not less than one-fourth of the required amount while the counties are responsible for the maintenance of the roads when constructed.

County roads.—These comprise all other public roads of the State and are constructed and maintained by county officials with county funds.

Turnpikes.—These are public roads improved at private expense, the owners of the roads receiving reimbursement through tolls collected. The turn-

TENNESSEE



* COUNTIES ORGANIZED IN ONE OF THE WAYS INDICATED

pike mileage of Tennessee is decreasing each year, and at the present time probably does not exceed 800 miles. Statutory control and supervision of turnpikes is exercised by the road officials of the counties in which the roads are located.

State highways may be improved in two ways, either by State and Federal funds, or by State or Federal funds in conjunction with local funds. The State highway commission has not definitely outlined its policy, but it is believed that the latter method will be almost universally followed. Under this plan the State highway commission and the local officials agree upon a road or section of road to be improved and joint funds are provided. The State is required to provide not less than one-fourth of the total cost of the work. All surveys for location and construction and supervision during construction are under the control of the State highway commission. When completed such roads are maintained by the county with county funds under State supervision. The State highway commission, however, has the right to take over the maintenance of such roads and any additional roads comprising the State highway system, if sufficient State funds are available for the maintenance thereof.

All construction dependent in whole or in part on Federal or State funds is under the complete control of the State highway department. Such work may be executed by State convicts, with approval of the Tennessee board of control, county or workhouse prisoners, by force account, or by contract. Contracts are let by the State highway commission and the State highway engineer assumes charge of the work and details a competent assistant to personally supervise it.

The State highways constructed with Federal or State funds are maintained by the State highway commission with State funds. The State highways constructed under the State-aid plan are maintained by the county with local funds, subject, however, to supervision and inspection by the State highway commission. Maintenance may be executed by contract, by force account, or by patrolmen. The patrol system has given satisfaction where adopted, and it is estimated that this system is in force in about 40 of the 96 counties. Detailed reports of the operation of the patrol system are furnished by the counties to the State highway commission at stated intervals. While county roads are constructed and maintained by county officials with county funds, State authorities may tender advice when requested to do so by the local officials.

REVENUES.

State.—The State highway commission is supported by funds obtained from 10 per cent of the gross revenues of the auto-license fund. The gross receipts from this source will amount to approximately $400,000 for the year 1918.

A State-wide tax of 1 mill on each dollar of valuation of all taxable property in the State is collected and constitutes the State-aid fund. This tax will yield approximately $700,000 in 1918. This fund is applied to the construction and maintenance of

State highways and during the period 1917 to 1921 must be so distributed that each county of the State shall have received at least $25,000 during the period.

Ninety per cent of the revenues from auto licenses are distributed among the counties in the ratio in which collected. This fund is expended by the county under supervision of the State highway commission for maintenance of State highways.

Local revenues.—Counties levy a tax on property and privileges for road purposes. The tax on property varies between 5 and 25 cents on a hundred-dollar valuation, a portion of which may be worked out. The tax on privileges shall not be less than one-fourth of the amount assessed for county purposes and not exceeding two-thirds of the amount of this tax may be paid in labor of the interested party at the prevailing wage. A labor tax of not less than 5 or more than 10 days of labor on the road is levied on each able-bodied male inhabitant between the ages of 21 and 50, and who is not exempt by law. This tax may be commuted at 75 cents to $1.25 per day. Counties may levy an additional tax for bridge purposes at a rate nor to exceed 20 cents on a hundred dollars. A few counties levy a turnpike tax of 10 cents on a hundred dollars. In a few counties of the State, a poll tax varying from $2 to $4, payable in cash, is levied instead of the labor tax above referred to. By special legislative authority some counties may require owners of wagons and teams to work them on the public roads the same number of days that statute labor is required.

BONDS.

Bonds may be issued by counties for road purposes for a period not exceeding 40 years and at a rate of interest not to exceed 6 per cent. The total of the bonds issued may not exceed 10 per cent of the total assessed valuation of the county, provided, however, that by a two-thirds vote of the legal voters, this amount may be increased to 15 per cent. The total county bonds outstanding on January 1, 1915, amounted to approximately $6,900,000. No State-road bonds have been issued.

TEXAS.

DEVELOPMENT.

State participation in road improvement in Texas is in its initial stage, authority therefor having been granted by the legislature in 1917, consists of money aid allotted to assist the counties in constructing a system of State highways, and is administered by a State highway department.

The system of State highways comprises 12,620 miles, or 9.8 per cent of the total State mileage, selected by the State highway engineer for improvement with Federal, State, and local funds. However, State aid may not be extended to more than 10 miles of road in a county during any one year.

On January 1, 1917, 12,000 miles, or 9.3 per cent, of the total road mileage were reported as surfaced. As this work was done by and at the expense of the counties, the improvements as a rule were located to serve local needs rather than to form connecting links in a State-wide system. The post road extending from Austin, the State capital, to San Antonio, a distance of about 70 miles, was constructed with local and Federal funds in accordance with the terms of the post-road act of August 4, 1912, and is the longest stretch of improved road in the State.

During the year 1916, $10,500,000 was raised and expended by local officials for road and bridge purposes.

During the year 1917, $10,010,000 was expended by all officials for road and bridge purposes.

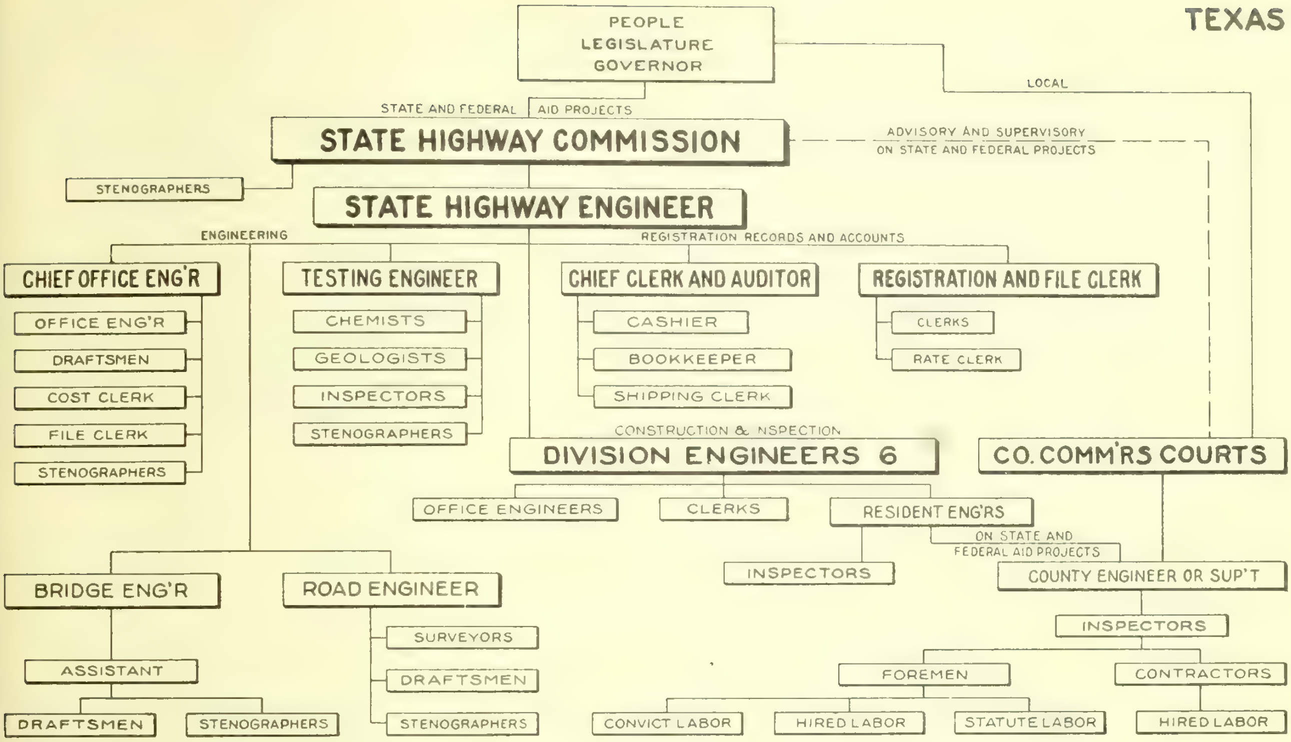
ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the accompanying diagram.

State.—At the head of the State highway department is the State highway commission, composed of three citizens appointed by the governor, with the consent of the senate, for a period of two years, the entire personnel changing at the end of each period. The commission is empowered with the administration of the State-aid law to formulate plans and policies for the location, construction, and maintenance of a comprehensive system of State highways and public roads in cooperation with the counties of the State, to establish rules for the conduct of the department, to advise with local officials relative to the improvement of county roads, to elect a State highway engineer, and collect and apportion the funds available from the registration and regulation of motor vehicles. The commission has appointed a secretary to administer the registration of motor vehicles and has provided him with the necessary clerks.

The State highway engineer is supported by a staff of engineers and appoints division engineers for each of the six districts into which the State has been divided. When convenient and expedient, county engineers will be appointed to these positions besides retaining their connections with their home county.

County.—Authority over road and bridge affairs is vested in a commissioners' court, created in each county by the election of a county judge and one commissioner elected for a term of two years each from each of the four districts of a county. The court may appoint a county engineer or road superintendent for the county or for each of the districts. Such officials are responsible for the administration of



the road program in the county or district. The county is required also to collect the fines for the violation of the motor-vehicle regulations and to enforce, after 1920, a wide-tire law, which prohibits carrying more than 2,000 pounds on a tire rim less than $3\frac{15}{16}$ inches in width.

The commissioners' court is required to divide the county into convenient road precincts and appoint road overseers and apportion the road hands for each precinct.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 128,960 miles of public road in Texas are, for the purpose of fixing responsibility for control, construction, and maintenance, divided into two groups, viz, State highways and county roads.

State highways.—These comprise 12,620 miles selected by the State highway engineer for improvement with Federal, State, and local funds. Initiative for construction is taken by the county court which makes application to the State highway engineer for Federal or State assistance. On approval of the project by the State highway engineer, plans, specifications, and estimates of cost are prepared under the direction of the county court and submitted to the State highway engineer for his approval. State or Federal funds are then provided in the ratio of one-fourth or under certain conditions up to one-half of the estimated total cost. The work may be executed by State prisoners under terms agreed to by the State highway commission and State prison commission and with the approval of the governor, or the work may be let to contract by the county board and supervised during construction by the county engineer or by a representative of the State highway department detailed at county expense. The work during progress is subject to inspection by the State highway department, and when the road has been completed and accepted by the State highway engineer the State's allotment is paid to the county. Payments during the progress of construction are made by the county court from the county funds.

Maintenance is executed by the counties in accordance with the rules and regulations issued by the State highway engineer. Failure to execute maintenance to the satisfaction of the State highway department results in withholding future allotments to the county.

County roads.—These comprise all other public roads of the State. They are improved and maintained by county officials at county expense. County prisoners may be utilized in the construction or maintenance of these roads, if so ordered by the county court. The various county courts of the State are required to consult with the State highway department relative to the expenditure of the proceeds of local bond issues when provided for roads of this group.

REVENUES.

State.—Funds are obtained from the retention of one-half of the net receipts obtained from the registration and licensing of motor vehicles. This fund for one-half of the calendar year 1917 amounted to about $400,000 and was allotted to the various counties to aid in the construction of State highways. During 1918 it approximated $1,000,000. The State generally contributes one-fourth of the cost, but may contribute to the counties of low assessed valuation one-half of the cost. These allotments are conditioned on the county providing, in addition thereto, an amount specified by the State highway commission.

County.—Funds for road and bridge purposes are secured by the imposition of a tax at the rate of 15 cents on each $100 of assessed valuation, and when authorized by a majority of freeholders of the county a special tax may be levied at the same rate. One-half of the net receipts from the registration and license of motor vehicles is returned to the county, in the ratio in which collected, for use in the maintenance of State highways.

Statute labor is required of all male inhabitants between the ages of 21 and 45 years for a period of five days each year, or in lieu thereof a cash payment of $1 per day for each day of labor so required.

BONDS.

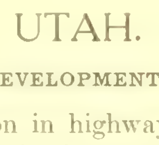
Sinking-fund bonds, in amounts not exceeding 25 per cent of the assessed valuation of the county or district, of terms not exceeding 40 years, may be issued by counties or districts when authorized by two-thirds of the taxpayers affected. On January 1, 1915, there was outstanding $14,615,016.53 of county bonds issued for road and bridge purposes. These bonds bore interest at rates of 5, 5½, and 6 per cent.

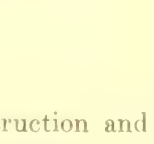
UTAH.

DEVELOPMENT.

State participation in highway construction and maintenance in Utah is of recent origin, a State road commission having been established in 1909 with power to select a State road system and to have charge of all funds appropriated by the State or the counties in the construction of this system. The State laws have been revised and amended from time to time until at present Utah is provided with a State road commission possessing broad powers over construction and maintenance of projects involving the use of State funds.

Seventeen per cent of the total public road mileage of the State has been hard surfaced and about 37 per cent of the total mileage has been graded and drained, principally under the State aid plan.





For the years 1918 and 1919 and each succeeding year thereafter an appropriation of $100,800 has been provided by the State for construction and maintenance of State and State-aid roads. A bond issue of $2,000,000 was authorized by the legislature of 1917 and the proceeds of this issue are to be devoted to road and bridge building purposes.

The total cash expenditure from all sources, State and local, for road purposes, for the year 1917, amounted to approximately $1,893,129. Of this total $120,200 of State funds and $822,929.44 of local funds were expended by or under supervision of the State highway department. State supervision thus extended to 48.3 per cent of all expenditures for road and bridge purposes.

ORGANIZATION.

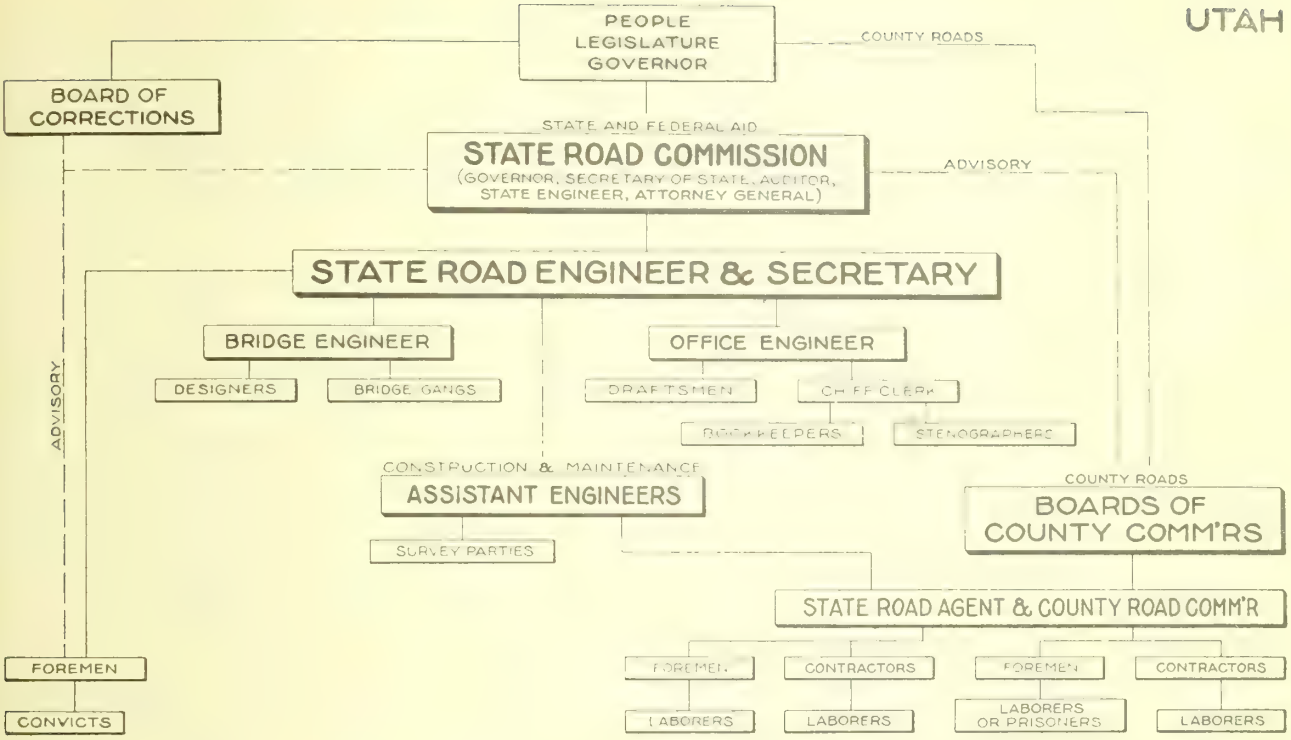
The organization of the highway forces of the State and the relations existing between them are shown on the chart.

State.—The State road commission is composed of the following ex officio members: Governor of the State, who is chairman of the commission; secretary of state, who is vice chairman; State engineer, attorney general, and State auditor, who serve without additional compensation.

The commission selects the system of State roads; has charge of the construction and maintenance of such roads; employs such engineer and clerical force as may be necessary; serves in an advisory capacity to county road and bridge officials and furnishes them on request plans and specifications and estimates of cost of roads, bridges, and culverts; and is required to prepare and issue a manual of road building and maintenance for the information and guidance of local officials in charge of such work.

The State road engineer appointed by the commission is assisted by a bridge engineer, an office engineer, several assistant and field engineers; also an office force of clerks, stenographers, etc. He is the executive officer of the commission and has active charge of all construction and maintenance of State roads. The State road commission appoints for each county an official, termed a "State road agent," who reports to the State road engineer. The county road commissioner is sometimes appointed State road agent, as he usually has the confidence of the county officials and is required to have a practical knowledge of road building. This official may act as inspector in charge of work let by contract to which State funds are contributed.

County.—County administration in Utah is vested in a board of county commissioners composed of three members elected for a term of two or four years. The board appoints a county road commissioner who assumes charge of the local roads of the county and employs and directs such help as



may be necessary to perform his duties, collects poll taxes due, and renders a report to the county board at the close of the year covering his operations. He also prepares plans, specifications, and estimates for road construction financed by county funds. Contracts for work of this nature are let by the county board. The county road commissioner, when designated "road agent" by the State road commission is considered the representative of the State road engineer and may assist in the construction and supervision of State roads.

CLASSIFICATION, CONTROL AND PROCEDURE.

The 8,810 miles of road of Utah are divided, for the purpose of fixing responsibility for control, construction, and maintenance, into three groups, namely, State roads, county roads, and trails.

State roads.—These, comprising a mileage of 3,660, are those roads designated by the State road commission and the county boards of commissioners. They are built under the direction of the State road commission with State and local funds.

The State road commission is required to notify each board of county commissioners on or before July 1 of each year of its intention to engage in State road construction in that county; to specify the amount of State funds available for the work, together with a general outline of the proposed work and a statement of the amount required to be appropriated from local funds by the county board.

Within 30 days from the date of the notice, the county commissioners are required to notify the State road commission of the amount appropriated or to be appropriated by the county for the purpose specified in the notice from the State road commission. This act constitutes the State road commission as agent of the county in all transactions connected with the construction of the proposed improvement and maintenance thereafter. In case of noncompliance by the county with the terms of the State road commission, the funds allotted to the county are held for the next yearly allotment among the various counties complying with the orders of the commission.

The State road engineer then prepares plans, specifications, and estimates of cost of the proposed improvement. The work may be done by force account under supervision of the State road engineer, or let by contract, in the discretion of the State road commission. When by contract, the State road commission, after due publicity prescribed by State law, awards contract to the lowest responsible bidder. The State road engineer designates a suitable representative or inspector to take charge of and supervise the work during its progress.

In making settlement for contract work, monthly estimates of work completed are prepared by the representative of the State road engineer and when approved by the State road engineer and State road commission are forwarded to the State auditor, who draws a warrant on the State treasurer. Payment of the final estimate is made in a similar manner, after the completed work has been accepted by or in the name of the State road engineer.

In the case of State road work, where conditions are satisfactory to the State road commission, convicts from the State penitentiary may, with the consent and under the rules and regulations of the State board of correction, be used to execute the work. All expense of this force, other than that for food, clothing, and bedding, is paid from the fund provided for the improvement. Completed State roads of all types are maintained by the State road commission, with joint funds—State funds being contributed in the same proportion as for construction.

County highways.—These comprise all of the roads in the county recognized by the county board as public roads and which are not included in the preceding system. They are opened, constructed, and maintained by the county board with county funds.

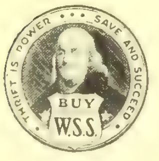
Trails.—Roads little traveled and not officially recognized by county boards as public roads are known as trails. No official provision is made for their repair or maintenance.

REVENUES.

State.—An annual appropriation of $100,800 has been provided by the State legislature for the support of the State road commission and for equal allotment to all counties. A $2,000,000 State bond issue has been authorized and the proceeds will be expended under the direction of the State road commission. The net receipts from the registration of automobiles, amounting to $170,707 in 1917, are used for the payment of interest on State bonds The balance, if any, is placed to the credit of the State road fund.

Each county auditor is required to certify to the State road commission, on or before October 1 of each year, data as follows: (*a*) The assessed valuation of the county; (*b*) the State road levy in mills; (*c*) the estimated amount of taxes to be derived from such levy.

Each county treasurer is required to certify to the State road commission on or before December 1 of each year the amount of money collected for State road purposes and the amount of delinquent taxes. On or before July 1 following each treasurer is required to certify to the State road commission the amount of delinquent highway taxes collected. From the data contained in these reports, the State road commission makes an equal allotment of funds provided by legislative authority among the 29 counties of the State. Counties accepting the allotments are required to provide an appropriation equal to one-fourth, one-half, or all of the full amount of the State allotment. Counties having assessed valuation of less than $2,000,000 provide one-fourth. Counties having assessed valuation between $2,000,000 and $4,000,000 provide one-half. Counties having an assessed valuation of $4,000,000 or more provide an amount equal to the State allotment.



County revenues.—The counties are authorized to levy a special road tax to provide funds for the construction of State roads. This tax rate is fixed by the State road commission and may not exceed 5 mills on the dollar valuation. Special taxes in cities, the proceeds of which are applied to the improvement of roads, are levied in counties receiving State aid when the regular 5 mills tax does not provide sufficient funds. Every able-bodied male citizen, between the ages of 21 and 50 years, not exempted by law, is required to pay a poll tax of $2.

BONDS.

State bonds to the amount of $2,000,000 were authorized in 1917. These bonds bear interest at the rate of 4½ per cent, are to be retired in 20 years, at the rate of $100,000 per year. The motor-vehicle license fee provides the fund for payment of principal and interest of this issue.

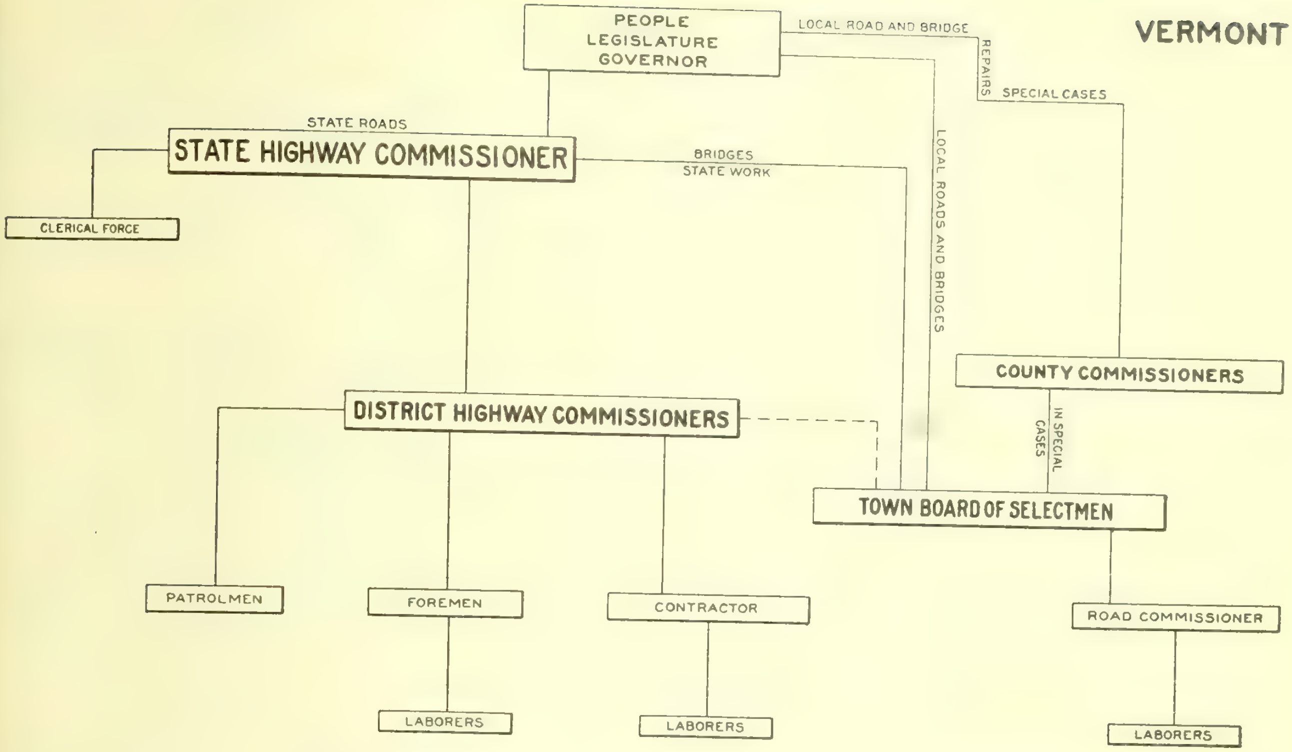
County bonds may be issued in an amount not to exceed 4 per cent of the total taxable valuation of the county, when the county board is authorized by a majority of the voters of the county. Such bonds are limited to a term of 20 years, and may not bear to exceed 5 per cent interest. On January 1, 1915, there was outstanding $281,500 of county bonds.

VERMONT.

DEVELOPMENT.

State participation in road improvement in Vermont is of State-wide scope, and has been extended since 1892. It consists of money aid to a system of State highways and main market roads, free technical advice and service to local road and bridge work, and is administered through and by a State highway commissioner.

State participation in its initial stage consisted in the levying of a uniform State-wide tax at a rate of one-half mill on each dollar of valuation and reapportioned among the various towns of the State in the ratio that road mileage of each town bore to the total road mileage of the State. While much benefit was secured from this form of taxation to road improvement which tended to assist the poorer towns at the expense of those more able to bear the financial burden, the lack of skilled supervision over road matters was apparent. To remedy this condi-



tion, the office of State highway commissioner was created by the legislature in 1898.

The powers and duties of the commissioner have been extended from the educational and advisory duties required in 1898 until he now has a considerable advisory control on bridges of 4 to 30 foot span constructed on State roads and receiving State aid, and quite complete control of such work of improvement over the maintenance of State roads as is done under State supervision. The system of State roads locally improved by each town comprises 28 per cent of the total road mileage of the State.

A total of 2,032.52 miles, or 13.4 per cent, of the total road mileage of the State has been improved since 1892, although some unknown portion of the mileage of the earlier years was undoubtedly not permanent improvement. Since 1907, 1,734.22 miles have been permanently improved. This includes the mileage in cities and villages as well as towns coming under State supervision. During the year 1916 $519,449.26 of State funds and $357,650.95 of local funds were expended by or under the supervision of the State highway commissioner. These figures do not cover expense of supervision or administration. The total estimated expenditures by all forces of the State for road and bridge purposes during that period reached $1,607,800. The State highway commissioner thus exercised supervision over about 54.5 per cent of all road and bridge expenditures in the State.

During 1917 $1,680,000 was expended by all road officials of the State.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the chart given herewith.

State.—At the head of the State highway department and in control of the construction of State roads done with State money or under the supervision of the State is the State highway commissioner, appointed by the governor with the advice and consent of the Senate for a term of two years. The commissioner is assisted in the discharge of his duties by an adequate clerical force and by district highway commissioners. The district commissioners represent the State commissioner in their several towns, locate the work, see that suitable plans and surveys are made, and supervise the work.

County.—The counties of Vermont do not initiate improvements or expend funds on road and bridge work. However, a county board of three commissioners appointed by the county court has power to make or cause to be made ncessary road or bridge repairs when the town officials have neglected or refused to make such repairs. The county commissioners act on petition of three or more citizens or taxpayers who have first invited the attention of the town officials to the necessity of making these repairs, and who then turn to the county board for relief. The expense of such repairs is borne by the town concerned.

Town.—Each town is governed by a board of selectmen elected annually by the qualified voters. The board has charge of and control over local road affairs and effects administration through one or two road commissioners who may be appointed by the board or who may be elected at the annual town meeting.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 15,111 miles of public roads in Vermont have been divided for the purpose of fixing responsibility for construction and maintenance into two groups, namely, State roads and town roads.

State roads.—These comprise about 4,300 miles of road designated by the boards of selectmen of the various towns with the approval of the State highway commissioner. Such roads are improved either with State or State and local. Funds, but are generally improved with joint funds. The initiative in new construction is taken by the town board which provides the necessary funds to secure an allotment of State funds. On approval of the project by the commissioner, surveys, plans, specifications, and estimates of cost are made under his direction and bear his approval. They are then forwarded to the town board, which is authorized by the commissioner to construct the work either by force account under supervision of the district highway commissioner or by contract let after due publicity. If done by contract, supervision during the progress of the work is exercised generally by the district highway commissioner or by an engineer inspector detailed thereto by the State highway commissioner.

Monthly payments, covering 85 per cent of the completed work as evidenced by the estimate prepared by the engineer in charge or the superintendent of the work, are ordered by the board of selectmen, and are paid by the town treasurer. Final payment for the completed work is ordered by the board of selectmen after the completed work has been accepted by the State highway commissioner or his authorized representative. Payment of the State's portion of the cost is then made to the town treasurer or by the State treasurer on a warrant of the State auditor, issued by him on certificate of completion made by the State highway commissioner.

Roads constructed in accordance with the above procedure and roads previously constructed by the town which are in a condition acceptable to the State highway commissioner, are maintained by patrolmen employed by the State under supervision of the district highway commissioner in accordance with regulations and rules issued by the State highway commissioner, at the joint expense of the State and towns.

Town roads.—All other roads of the State are town roads. They are maintained by and at the expense of the town, provided that a town may secure at the expense of the State the services of an engineer to make surveys, plans, specifications, and estimates of cost and to supervise the construction of any bridge of 4-foot span or over. Bridges of 30-foot span or over constructed in accordance with the above conditions may, at the discretion of the State highway commissioner, receive an allotment of State funds to the extent of 33⅓ per cent of the cost, provided, however, that the allotment may not exceed $400.

REVENUES.

State.—The funds at the disposal of the State highway commissioner are obtained and allotted as follows:

1. An appropriation by the legislature of $260,000 per annum which is allotted in amounts not less than $100 nor more than $1,000 to towns providing an equal amount, the combined fund to be expended on State roads, and the remainder of the appropriation is expended at the discretion of the commissioner under such arrangements as he may make with the towns benefiting by the improvement.
2. Receipts from the registration of motor vehicles are used for the maintenance of State roads. It is estimated that this fund will produce about $326,032 in 1917.
3. An appropriation of $25,000 for State aid to bridge construction.

Towns.—Funds are obtained in part from the imposition of a State-wide tax of one-half mill on each dollar of valuation which produces annually about $125,000, and which is reapportioned among the towns in the ratio that their road mileage bears to the total road mileage of the State. Additional funds for town roads are provided by majority vote at the annual town meeting. The sum so authorized for road and bridge purposes is raised by taxation as a part of the general town fund and is expended by order of the town board of selectmen.

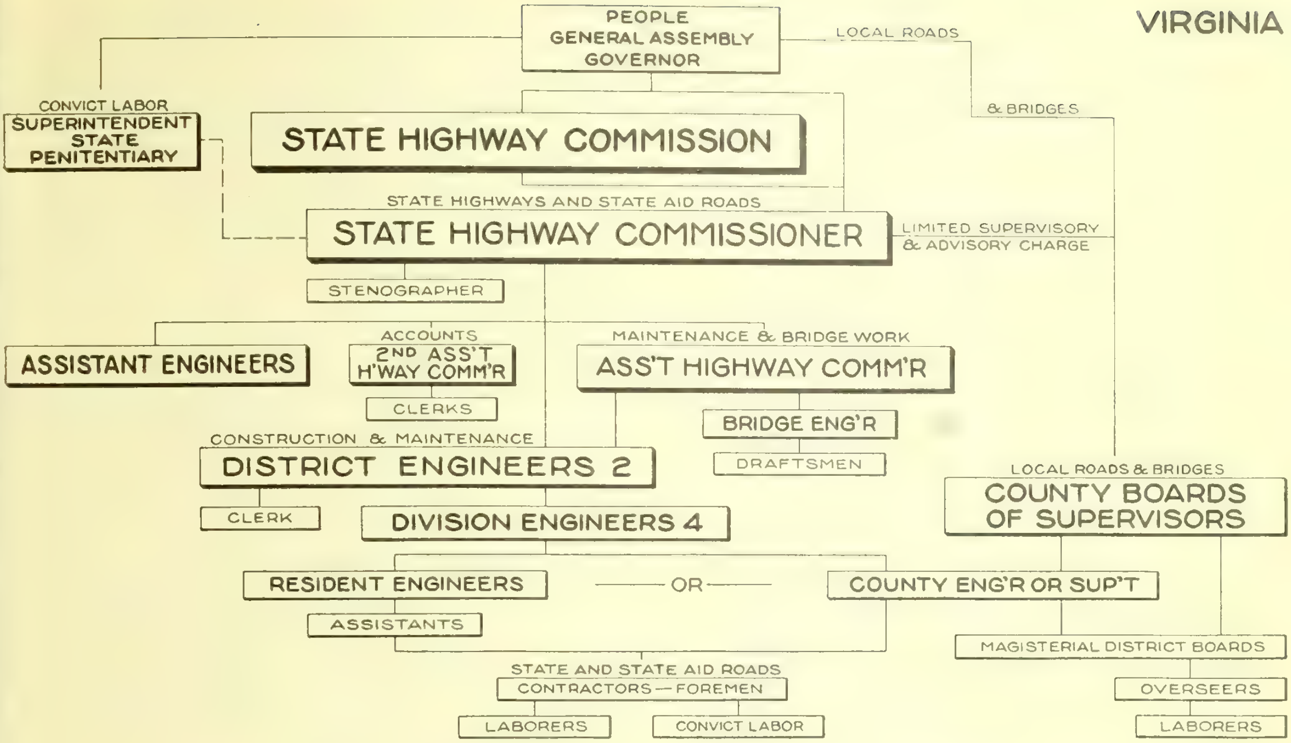
State or town bonds have not been issued in any appreciable amount in Vermont for road and bridge purposes.

VIRGINIA.

DEVELOPMENT.

State participation in public road improvement, as a State policy, dates from 1906, consists of money aid and convict labor applied to a system of State highways and to a system of principal roads selected by the various counties, and is administered by a State highway commission.

Turnpike construction was instituted in Virginia as early as 1785, and during the 50 years following a considerable mileage of road of this type was constructed, in which the State and various counties owned stock. With the rise of the railways as a transportation agency many of these roads began to be unremunerative and were allowed to deteriorate, and finally became public roads under the control of the public officials.



With the decrease of State and county interest in turnpike construction and operation, control of the greater portion of the road mileage of the State passed into the hands of county and district officials who, for a period of 50 years or more, were handicapped by inadequate funds and lack of technical knowledge of the principles of construction and maintenance of durable roadways. To remedy this condition the general assembly, in 1906, authorized the use of State convicts on highway work and also authorized the organization of a State highway commission with supervisory and advisory duties. This assistance was supplemented in 1909 by the grant of money aid to counties not receiving convict labor and the policy was further strengthened in 1918 by the selection of a State-wide system of State highways, to be constructed and maintained at State expense.

At the close of the year 1916, 5,500 miles, or 10.3 per cent of the total road mileage of the State had been surfaced. Of this total, 4,463 miles had been improved by means of State-aid combined with local funds.

The expenditures for road and bridge purposes during 1916 by all forces of the State were as follows: State funds to the amount of $542,524, and local funds to the amount of $1,348,725 were expended by or under the supervision of the State highway commission, while $1,364,825 were expended by local authorities. Thus, the State contributed 16.6 per cent and exercised supervision over 58 per cent of the total expenditures. During 1917 $4,137,000 was expended for road and bridge purposes by all road officials.

ORGANIZATION.

The organization of the road forces of the Commonwealth and the relation existing between them is shown on the accompanying diagram.

State.—Control and supervision over road construction and maintenance is vested in a State highway commission, composed of the State highway commissioner and a professor of civil engineering from each of the following institutions: The University of Virginia, the Virginia Military Institute, and the Virginia Agricultural and Mechanical College.

The State highway commissioner, appointed by the governor for a term of six years, is required to be a competent civil engineer and a resident of the State. He is executive official of the highway department, and through a force of assistants consisting of an assistant commissioner, second assistant commissioner in charge of accounts, bridge engineer, two district engineers, four division engineers, and such other assistants as may be required, has charge of or supervision over all work to which Federal or State funds or State convict labor is contributed. The department has full supervision over construction and maintenance of the State highway system, and general supervision over the main traveled roads of the State, and may make recommendation to the local authorities having jurisdiction or to the governor of the State with regard to their condition and as to means for their improvement.

The State highway commissioner may detail competent assistants to counties at county expense to take charge of new construction, instituted with the proceeds of bond issues, or he may make such detail whenever requested by the county officials.

County.—Road affairs in each county are administered by a board of supervisors, one being elected from each district in the county. The number of districts in the county may vary from three to nine. Each elective supervisor has supervisory charge of the road and bridge affairs in the district represented by him. General administration of road improvement or maintenance of county roads is vested in an official termed a "county superintendent," or "district superintendent." Such officials are appointed by the county board, generally on recommendation of the State highway commissioner. County engineers may be employed by the county board if deemed necessary.

Of the 100 counties in Virginia many enjoy the benefits of special road legislation. Therefore, the organization and powers of the county road forces are not uniform throughout the State. The board of supervisors of most counties may adopt for their county any special road act applicable to any other county in the State. However, a few counties are prohibited by State law from carrying out this procedure.

District.—Counties are usually divided into magisterial districts, and road matters therein are administered by a board composed of the supervisors, district superintendent, who is usually a deputy county superintendent, and one other member.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The public roads of Virginia, with a total mileage of 53,388, are divided for the purpose of fixing responsibility for control, construction, and maintenance into three groups, namely, State highways, State-aid roads, and county roads.

State highways.—These comprise 28 routes with a total mileage of 3,500 selected by the general assembly for improvement with Federal funds, State funds, State convict labor, and local funds. All stages of construction and maintenance are under the supervision of the State highway commissioner. Maintenance is executed by the State highway commissioner at State expense.

The 4,463 miles of main traveled road improved prior to 1918 at State and local expense are now included either in the State highway system selected by the general assembly or in the system of main traveled county roads selected in each county by the county board subject to the approval of the State highway commissioner for improvement at joint expense.

State aid.—Unimproved roads selected in the above manner may be improved in accordance with the following statutory requirements: The sum of $300,000 per annum provided by the general assembly for State aid is apportioned to the counties of the State not receiving convict-labor aid, the rate of apportionment being in proportion to the amount of State tax paid by each county participating. Convict labor is apportioned among the various counties in the order of their application; provided, however, a county may not secure such service for a longer period than five years if other counties desiring such services are unsupplied.

Plans, specifications, estimates of cost, etc., for work of this class are prepared by or under the supervision of the State highway commissioner, and are submitted to the county board for inspection and approval. Upon acceptance by the board bids, if the work is to be let by contract, are requested by the State highway commissioner, and contracts therefor are let by the board with his approval.

Supervision and inspection during the progress of the work is exercised by an assistant engineer detailed by the State highway commissioner, the expense of the engineer being met by a special fund composed of not to exceed 5 per cent of the joint fund available for the work.

Monthly payments covering 90 per cent of the completed work, as evidenced by the estimate of the engineer in charge, are made by county officials, the State's portion of the cost being transferred to the county treasury by order of the State highway commissioner whenever such funds are needed. Ten per cent of the contract price is retained until the work has been completed, accepted, and undergone 90 days' actual use.

The county authorities may determine what proportion of the local share of the cost shall be borne by the district or districts of the county benefiting from the improvement. Completed roads of this group are maintained by the counties at county expense, although the State highway commission may, and in a few instances has, allotted State funds for this purpose.

County roads.—These comprise all other roads of the State. They are opened, controlled, constructed, and maintained by county or district boards with local funds. When the county roads are improved with the proceeds of bond issues, the work is required to be done in accordance with plans and specifications furnished by the State highway commissioner and under the immediate supervision of an engineer approved by or detailed to the county by the State highway commissioner.

REVENUES.

State.—State funds for road improvement purposes are provided by the general assembly as follows: For the fiscal year beginning September 1, 1918, $425,000 has been appropriated for the State highway system. For the same period $200,000 has been appropriated for the support of the convict road force, $300,000 has been appropriated for aid to county highways, and $39,000 as the State's highway contingent fund for the support of the State highway department. In addition thereto the net proceeds of the motor vehicle license fund, estimated at $475,000, are placed at the disposal of the State highway commission for highway purposes. The latter fund may be used for the maintenance of the State highway system or allotted to the various counties of the State for construction purposes under the State-aid plan or for the maintenance of State-aid roads already constructed. Thus for the calendar year 1918 a total of $1,439,000 has been made available for State participation in highway improvement. The general assembly has also provided a State tax of 3 cents on each $100 valuation and it was estimated that about $375,000 raised by this means would be available for expenditure on January 1, 1919.

County.—Road funds are secured from a general tax levied at a rate of not to exceed 40 cents on each $100 assessed valuation. District funds are secured from a general tax levied at similar rates, provided, however, that when the combined proposed county and district tax exceeds 15 cents on each $100 assessed valuation, the proposal must be decided by a majority of the districts concerned.

BONDS.

Bonds may be issued for road construction purposes by counties or by districts when authorized by a majority of the voters concerned in an amount not exceeding 10 per cent of assessed valuation of the county or district. Such bonds when issued may not run to exceed 34 years at rates of interest not exceeding 6 per cent. While the bonds are of the sinking-fund type the county or district has the right to redeem the bonds on call therefor. Counties having a population of 300 or more persons per square mile of area may issue bonds in an amount not exceeding 18 per cent of the total taxable valuation of the county. On January 1, 1915, $5,650,994.93 of county and district road and bridge bonds were outstanding.

WASHINGTON.

DEVELOPMENT.

State interest in and assistance to road and bridge improvement in Washington has become a fixed State policy and is applied to a State-wide system of roads designated by the legislature and to local roads of importance selected, with the approval of the State highway board, by local officials.

State-aid was extended in territorial days by the appropriation by the legislature of special funds for the construction of certain roads under the supervision of local commissioners named in a special act of the legislature. The counties benefiting were required to provide funds equal to 50 per cent of the amount thus appropriated. This practice was continued for several years after statehood was accomplished, but was finally abandoned. In 1905 the offices of the State highway commissioner and the State highway board were created to supervise the expenditure of a fund provided for State aid in the constructing of 12 designated State roads.

A State-aid law providing for State assistance to local roads of importance was enacted in 1907, and funds were provided for carrying its provisions into effect. However, in 1911 this law was repealed and the "permanent highway law" was enacted to provide a more equitable manner of apportioning State aid. State aid has been extended by means of special legislation to the construction of bridges of more than local importance in communities unable to bear the total financial burden imposed by such improvements.

From time to time the system of State roads has been extended until this system now comprises 3,365 miles, of which on January 1, 1917, 951 miles, or 28¼ per cent, had been surfaced. On the same date 894 miles had been surfaced under the terms of the "permanent highway act." Of the 42,428 miles of public road in Washington 5,900, or 13.9 per cent, were reported as surfaced on the date above quoted.

Expenditures for road and bridge purposes during the year 1916 reached a total of $7,518,343, of which $859,672 were State funds and $2,104,340 were local funds expended by or under the supervision of the State highway board. The State thus contributed about 11½ per cent and supervised the expenditure of about 39 per cent of the total.

During 1917 a total of $7,116,000 was expended by all road officials of the State.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown on the diagram.

State.—At the head of the State highway department is a State highway board composed of the governor as chairman, the State auditor, the State treasurer, a member of the public service commission, and the State highway commissioner, who is appointed by the governor, and who serves as secretary of the board and is executive official of the State highway department.

The assistant highway commissioner, appointed by the commissioner, with the approval of the board, has general charge of the clerical department, right of way department, and administrative charge of the engineering department.

The chief engineer, in charge of the engineering department, is appointed by the commissioner. Other employees, technical and clerical, are appointed by the commissioner as needed. Location and construction parties are under the supervision of a district engineer or assistant engineers. State superintendents or resident engineers are detailed to take charge of the construction of State roads and bridges.

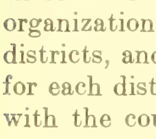
The State highway department has charge of all steps of construction of State roads and bridges, provides standards of construction for local roads and bridges, and is required, on request, to provide local road and bridge officials with plans, specifications, and estimates of cost of such work or to furnish advice on local road and bridge matters.

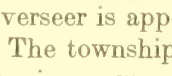
County.—Each county is governed by a board of three commissioners, elected for terms of three years from the three districts into which the county is divided. The county clerk and county treasurer are respectively secretary and fiscal agent of the board. In each county a county engineer is elected every two years. He serves as the county official in charge of the road and bridge construction and maintenance instituted under the direction of the board. Supervisors are appointed by the board for each road district of the county. The commissioner of each district exercises supervision over the supervisors thus appointed.

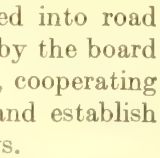
Township.—Boards of supervisors consisting of three elective members, are vested with administrative powers over local roads and bridges (only three counties of the State have adopted township organization). The township is divided into road districts, and an overseer is appointed by the board for each district. The township board, cooperating with the county engineer, may open and establish new highways or alter existing highways.

Special districts.—These may be authorized by the county boards to carry out road improvements under the assessment plan. Such districts are administered by a board of three supervisors. This board is required to cooperate with the county engineer in all matters relating to construction and assessment of final costs.

Independent highway districts.—Such districts may be constituted by the county board when authorized by a majority of the voters of the territory affected. The affairs of such districts are administered by a board of three elective directors. This board may, under certain conditions, construct and maintain roads and issue bonds to defray the cost of construction.







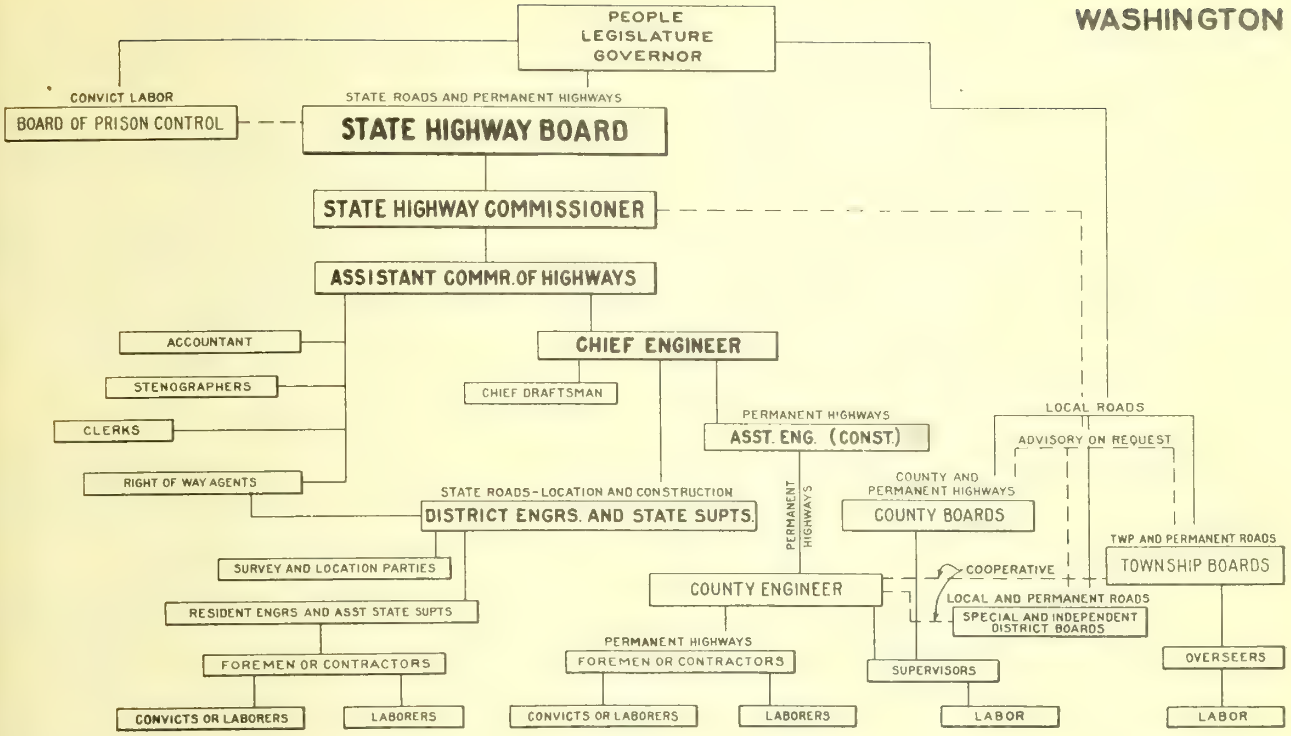
CLASSIFICATION, CONTROL, AND PROCEDURE.

The 42,248 miles of public road in Washington are, for the purpose of fixing responsibility for control, construction, and maintenance, divided into four groups, viz, State roads, permanent highways, county roads, and toll roads.

State roads.—These comprise 2,112 miles of primary highways and 1,263 miles of secondary highways, selected by the State legislature for improvement by the State highway department with funds provided by the legislature, the amount available for expenditure on each section being specified in the appropriation. All surveys required, plans, specifications, and estimates of cost, letting of contracts, supervision of work during progress, and final acceptance thereof on completion of roads of this group are administered by the State highway department. Convict labor, subject to the control and management of the State board of control, may be utilized by the State highway department on road work coming under their jurisdiction. Maintenance of roads of this group is executed by and at the expense of the county; maintenance of primary highways being subject to supervision by the State highway department. Funds used by the county for maintenance of State roads are taken from the county permanent highway maintenance fund.

Permanent highways.—An improvement under the permanent highway laws is initiated by resolution by the board of county commissioners, either on their own motion or following a petition of the owners of two-thirds of the linear frontage of lands along the road sought to be improved A certified copy of this resolution is sent to the State highway commissioner, who is required to make an investigation to determine if the road designated is of sufficient importance to merit improvement under the provisions of the act. In case the proposed improvement receives the highway commissioner's approval, the county engineer, or a construction engineer employed by the county board, is directed to prepare plans and specifications and an estimate of cost of the improvement at county expense. These are forwarded to the highway commissioner for his approval, rejection, or revision, and returned to the county commissioners, who formally adopt the approved plans by resolution.

The work during progress is under the supervision of the county engineer or construction engineer. Monthly payments covering 80 per cent of the completed work may be made when based on estimates prepared by the engineer in charge and which bear the approval of the county board and the State highway commissioner. Final payments are made



when the work has been examined and accepted by the State highway commissioner. When the improvement is initiated by petition of the abutting property owners not to exceed 85 per cent of the total cost is borne by the "permanent highway fund," and not less than 15 per cent is borne by the owners of the abutting and adjacent property. Property so taxed extends not less than 660 feet and not more than 3 miles on either side of the highways. The land so taxed is divided into three zones bearing seven-fifteenths, five-fifteenths, and three-fifteenths of the total cost assessed against the property, the rate of taxation being inverse to the distance from the highway. Maintenance of roads of this group is executed by the county from the county permanent highway maintenance fund. Roads improved by this method may be either State roads or county roads, the intent of the law being to provide a method of improving roads of local importance or parts of important State routes.

County highways.—These comprise all other public roads of the State. They are improved at the expense of the counties and townships.

Toll roads.—County roads may be improved by and at the expense of private corporations and tolls collected from the users thereof. At the expiration of the franchise the roads revert to the public.

REVENUES.

State.—State funds for highway improvement are raised by a State-wide tax of 1 mill for State highways and a State-wide tax of 1½ mills for the "permanent highway fund." As the budget system prevails in Washington, the proceeds of these taxes are appropriated by the legislature for specific purposes, as follows:

1. For State roads for the two years 1917 and 1918, $1,939,301.28. The routes to be improved and the amounts available therefor are specified in the act of the legislature.
2. For the "permanent highway fund," $4,992,198.18 to be expended among the various counties in the ratio in which collected.
3. For the support of the State highway department, $64,820.

The State has thus made available for the two-year period $6,996,319.36.

County.—The county permanent highway maintenance fund for maintenance of State and permanent highways and roads of like character is composed of 5 per cent of the "permanent highway fund," allotted the county by the State and the proceeds from automobile license fees, fines, and collections. A portion of the net motor licenses is apportioned among the counties in the ratio of $100 per mile for maintenance of primary highways, and the remainder of the fund is applied to maintenance of permanent highways and other roads of like character. Other funds for county road and bridge purposes are obtained by a general county tax of 4 mills, and a district tax of not more than 10 mills levied in each district for road and bridge purposes.

Township.—The ordinary road and bridge tax levied in the township may not exceed 8 mills on each dollar of assessed valuation.

BONDS.

Counties or townships when authorized by a three-fifths majority of the voters of the county or township may issue bonds in an amount not exceeding 5 per cent of the assessed valuation of the county or township. The bonds are required to be of the sinking-fund type, bear interest at a rate not exceeding 6 per cent, and may not run more than 20 years.

Independent districts may, when authorized by a majority of the voters, issue bonds in an amount not exceeding 5 per cent of the assessed valuation of the district. Such bonds may bear 6 per cent interest, and are required to be of the deferred serial type, limited to a term of not more then 20 years, and may be payable 10 years from the date of issue. State bonds for bridge purposes, and county bonds for road and bridge purposes outstanding on January 1, 1915, amounted to $1,555,000.

WEST VIRGINIA.

DEVELOPMENT.

State participation in road and bridge improvement in West Virginia is of recent origin, limited in amount, although of State-wide scope. State interest in road improvement may be said to date from 1907, with the appointment of a State highway inspector, who was empowered to investigate the conditions of the roads throughout the State and to make recommendations to the legislature concerning such new legislation as in his opinion would be beneficial. The office of public roads, administered by a commissioner of public roads, with limited supervisory and advisory duties over road and bridge matters, was created in 1909 and abolished in 1911. The State road bureau was created in 1913. State financial aid was not annually extended until 1917, at which time the State highway department was reorganized and a system of State roads was designated. The principal duties of the State road officials prior to 1917 were to furnish advice and supervision when requested by the county officials having charge of local improvement.

The system of State roads designated in 1917 comprises about 14 per cent of the total road mileage of the State, and will be constructed under the supervision of the State highway department.

The main traveled roads of West Virginia comprise about 20 per cent of the total mileage of the State, and about one-fourth of these roads, or 1,600 miles of the total, have been improved by surfacing.

Practically all of the road improvement in the State has been carried out by the counties, which, under the State law, are invested with broad powers over road work, subject, however, to limited State supervision.

The State, during 1916, expended $10,967 for support of a highway department and the counties expended about $5,500,000 for road and bridge improvement.

During 1917 a total of $8,200,000 was expended by all road officials of the State.

West Virginia is traversed by mountain ranges from north to south and presents difficult problems in road location and construction, although, generally speaking, road material of good quality is abundant in the eastern and western parts of the State, and is scarce in the central portion of the State.

ORGANIZATION.

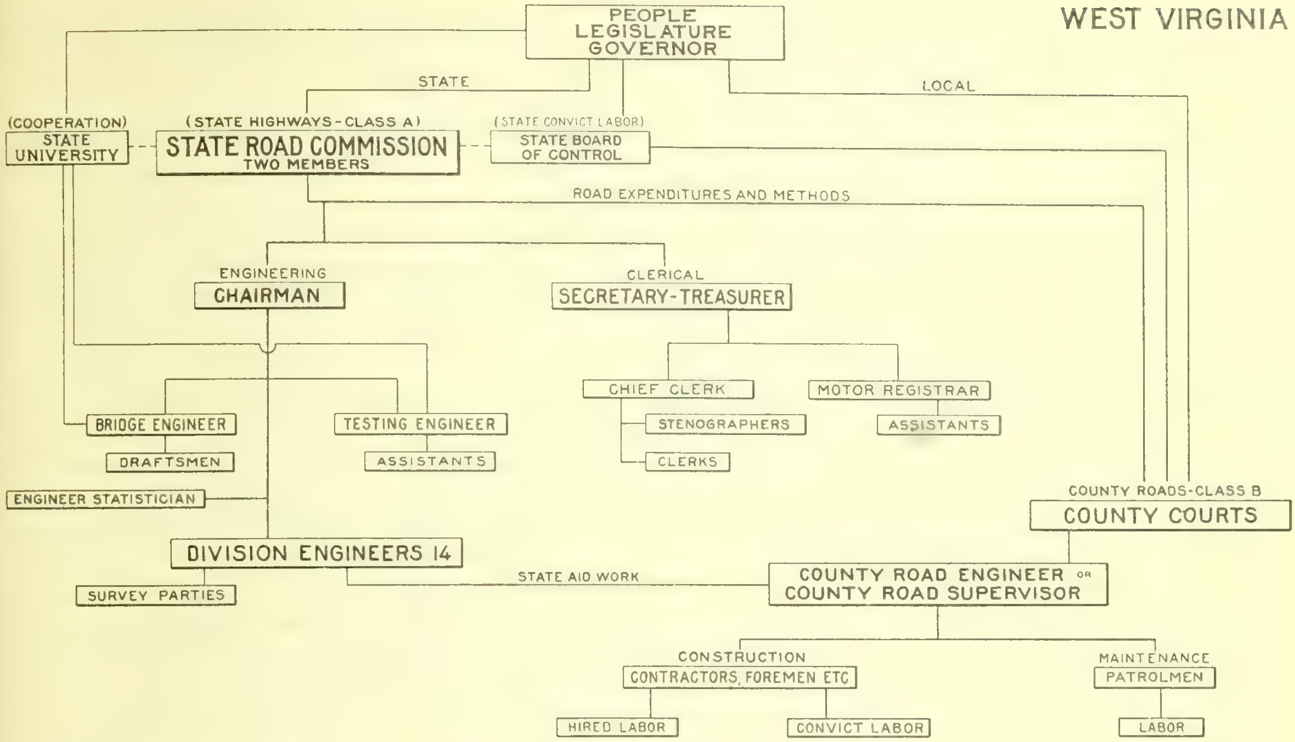
The organization of the road forces of the State and the relation existing between them is shown on the diagram.

State.—The State road commission is composed of two members, appointed for terms of four years by the governor of the State, with the advice and consent of the State senate. The members are required to be citizens and residents of the State and to represent the two leading political parties of the State. One member is required to be a practical civil engineer of known business qualifications and who shall have had at least three years' responsible charge of the construction and maintenance of public roads and highways. The other member of the commission is required to be of known and successful business qualifications, and one member is designated by the governor as secretary-treasurer of the commission.

The commission elects one of its members as chairman and has the power to select and fix the compensation of such assistants, agents, or employees as may be required to carry out its duties. The commission collects all the fees due the State under the motor vehicle and chauffeur law, issues licenses therefor, establishes rules and regulations relative to the repair and improvement of class A roads by county engineers, tests materials proposed to be used in improvements dependent in whole or in part on Federal funds, has the power to investigate any or all expenditures made by the various counties of the State for road construction and maintenance, and to cause prosecution of officials failing to adopt proper methods of construction and maintenance or to provide proper supervision and inspection.

The commission is required to prepare at the expense of the county plans and specifications and estimates of cost for the improvement of any public road of the State when requested by the local officials having jurisdiction.

County.—County road and bridge administration is vested in a county court composed of elective members designated as judges. The county clerk



is clerk of the court and the county sheriff is ex officio tax collector and treasurer. The county court has power to fix tax rates and provide for the collection thereof and to enter into contracts for road and bridge improvement.

The county engineer or county supervisor, appointed by the county court for a term of two years, is required to be a practical road builder. He is executive officer of the court in all matters pertaining to road and bridge construction and maintenance. In matters concerning class A roads, he is subject to rules and regulations and orders of the State road commission. He is also required to assist the State road commission in its campaign of creating public interest in road improvement. It is the duty of the county engineer or county supervisor at the end of each fiscal year to ascertain and to report in writing to the county court the amount of money necessary to open and keep in repair all main county roads and the roads of each of the magisterial districts during the ensuing fiscal year. The court may amend the report as it may think proper. However, the sections of the report showing the amount required for maintenance of class A and class B roads are used by the court in laying tax levies for road purposes.

The county may be divided by the court into sections and a road patrolman appointed for each magisterial district who is required to patrol daily, except Sunday, the roads of his district and to execute such repairs as may be necessary and to superintend persons performing statutory labor on the road.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 32,024 miles of public road of West Virginia are for the purpose of fixing responsibility for construction and maintenance divided into two groups, namely, class A and class B roads.

Class A roads.—These comprise about 4,600 miles of road selected by the county courts of each county, subject to the approval of the State highway commission. These comprise two or more main roads of the county, and all roads selected must connect with similar roads in adjoining counties. Other main roads may, on request of the county court, be added to this system from time to time with the approval of the State road commission.

Roads of this group are improved with joint funds provided by the State and county, the State funds for road purposes at the disposal of the State road commission being allotted among the counties on the basis of class A mileage in each county, conditioned, however, that the county provides an equal amount. The roads of this group are improved in accordance with plans and specifications furnished at the cost of the county and approved by the State road commission. Improvement is executed by the county subject to supervision by the State road commission or its authorized agent. The work of construction may be done by force account, convict labor, or by contract.

When by convict labor, convicts not less than 10 in number are furnished under contract entered into by the State board of control and the county court. The work during progress is under general supervision of the State road commission. When executed under contract let by the county court, the State road commission is notified in advance of the date of letting and is required, if requested, to furnish the county court for its private use an estimate of the reasonable cost of the improvement. Supervision of the work in progress is vested in the county engineer or supervisor.

Monthly payments to the contractor based on an estimate prepared by the engineer or supervisor in charge are made by the county treasurer on order of the county board. Payment of the State's portion of the cost is made to the county as the work progresses by order of the State road commission, the payments being based on an estimate prepared by the county engineer or county supervisor. During the progress of the work, an amount not to exceed 20 per cent of the contract price is withheld, and on completion this amount is not turned over to the contractor until the work has been accepted and a reasonable time has elapsed.

Improved roads of this class are maintained by county forces with county funds, the maintenance being subject to inspection by the State road commission, or its authorized representative. Future allotments to the county may be withheld when maintenance is not executed to the satisfaction of the State road commission.

The county engineer or supervisor is required to report monthly to the State road commission relative to all transactions concerning construction and maintenance and the costs thereof of all Class A roads under his jurisdiction. Maintenance may be executed by patrolmen, by force account consisting of statutory or paid labor, or sections of road may be sold to the lowest bidder.

Class B roads.—These comprise all other public roads of the State and are located, constructed, and maintained by county officials with county funds. However, on request of the county officials the State road commission is required to investigate materials proposed for use in improvement of roads of this group, and to advise as to methods of construction and maintenance. The amount of work pertaining to roads of the group thus voluntarily placed under the control of the State road commission is increasing each year.

REVENUES.

State road fund.—The net revenues accruing from the registration and license of motor vehicles and chauffeurs are deposited in a fund called the State road fund. This fund may be increased by appropriations by the legislature. The expense of the State road commission, limited by the legislature to $63,700 per year for the years 1918 and 1919, is paid from this fund. The remainder, about $276,000 for 1918, is allotted among the various counties of the State for construction and maintenance of class A roads in proportion to the mileage thereof. However, counties do not receive both State and Federal funds.

Motor vehicles engaged in transporting passengers or freight over regular routes pay a privilege tax in an amount determined by the commission. Ninety per cent of the tax obtained from this source is returned to the county or city originating it for maintenance of the roads actually used by such vehicles. The remaining 10 per cent is added to the State road fund.

County revenues.—County revenues for road and bridge purposes are in part obtained from a general levy, laid by districts, on all property at a rate not to exceed 15 cents on the $100. In cases of emergency it may be increased by an additional levy not to exceed 10 cents on the $100.

The county court shall levy a capitation tax of $1 per year on all males 21 years of age or over and not otherwise legally exempt or may require four days' road work from such persons.

The county in addition to this may levy a tax of 25 cents on each $100 for class A roads and in addition may levy an emergency tax of 10 cents on the $100 when required for such roads, and may set aside a part of the general county levy of 30 cents on the $100.

BONDS.

The county court, when authorized by a three-fifths vote, obtained at an election held for that purpose throughout the county or such portion thereof as may be affected, may issue bonds for the purpose of road or bridge improvement, or instead of bonds a special tax levy for a period not exceeding 10 years may be laid. The proceeds obtained from the sale of bonds or from the special levy are expended under the supervision of the State road commission.

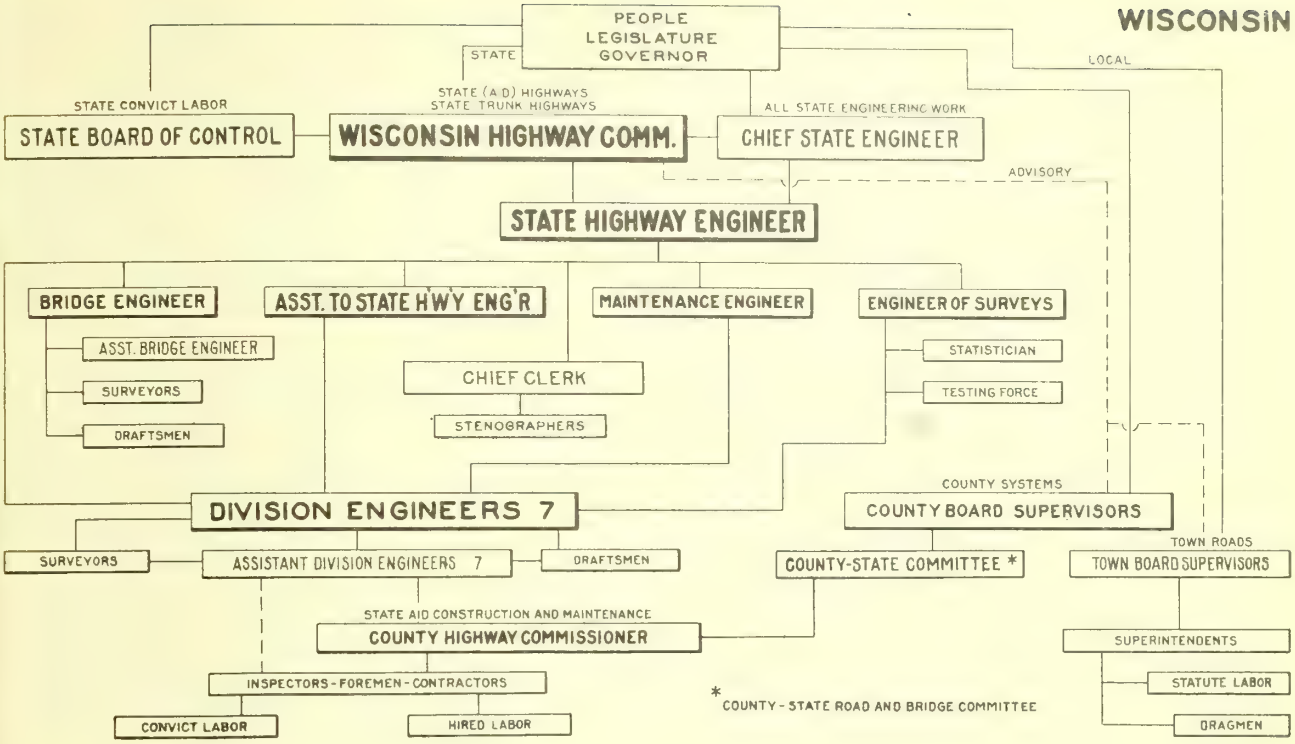
No State bonds have been issued for road purposes. Bonds issued by counties for road and bridge purposes amounted on July 1, 1917, to $16,941,500.

WISCONSIN.

DEVELOPMENT.

State participation in road improvement in Wisconsin is of comparatively recent origin, of State-wide scope, is extended in the form of money aid, technical advice, and supervision of construction and inspection of maintenance, and is administered through the State highway commission.

Centralized control of road improvement had its beginning in the county aid road law passed in 1898 and was further supplemented in 1907 with the enactment of a law requiring the designation of a



county road system to be administered under the supervision of a county highway commissioner in each county. The expense incident to the designation of these systems was borne jointly by the county and township boards.

In 1907 the State geological and natural history survey instituted a free consulting engineering service for the benefit of county and township road officials. In 1911 a State highway commission was created and a policy of State money aid was inaugurated. The State highway commission, whose engineering staff is now a division of the State department of engineering, has control over the system of State trunk highways connecting all county seats and towns of 5,000 or more inhabitants, the State-aid funds, and supervision of the maintenance of such roads when constructed.

State-aid funds have been expended on county systems of prospective State highways which when completed will form the State highway system. The improvements have generally been made in accordance with local interests, with the result that isolated systems of market roads have been created rather than improvements of a State-wide system connecting the various sections of the State.

As the State trunk highway system was not authorized until 1917, little work has been done other than designating its location. The system as outlined comprises about 6½ per cent of the total road mileage of the State.

The county systems eligible for State aid, which when completed will form the State highway system, comprise 26 per cent of the total road mileage of the State. In many cases, the two systems of roads will overlap, and where this occurs the section concerned will be designated a State trunk highway. At the close of 1916 about 20 per cent of the total mileage of public roads of the State had been hard surfaced.

During the year 1916, $950,000 of State funds and $4,120,764 of local funds were expended by or under the supervision of the State highway commission. The total expenditure during the year by all road forces of the State reached $10,570,764. State supervision thus extended to 48 per cent of the expenditures for road and bridge purposes.

During 1917 a total of $9,887,000 was expended for road and bridge purposes by all road officials of the State.

ORGANIZATION.

The organization of the forces of the State for highway control and improvement and the relation existing between them is shown on the chart.

State.—The State's participation in highway work is exercised through the State engineering department headed by the State engineer, who is in charge of all engineering work in the State in which the State has investment. The State engineer is appointed by the State railroad commission.

The State highway commission is composed of five members, two being ex officio members, namely, the dean of the College of Engineering of the State University, and the State geologist. The three appointive members are appointed, one every two years, by the governor for terms of six years.

The State engineer appoints, subject to the approval of the State highway commission, the State highway engineer, who, as executive official of the State highway commission, is required to secure his instructions on engineering matters from the State engineer and on all other matters from the State highway commission. Such technical assistants as may be required by the commission are detailed thereto by the State engineer.

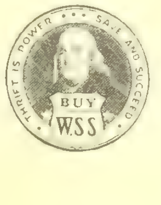
In fixing the final location of the State trunk highway system the State highway commission was assisted by a committee of five members of the legislature designated by the governor.

The State highway commission, subject to the above limitations, exercises supervision over construction and maintenance of the State trunk highways and the State highway systems, and allots funds at its disposal for the two systems above designated to the various counties of the State.

For administrative purposes the State is divided into eight divisions, each in charge of a division engineer who reports directly to the State highway engineer.

County.—The county board of supervisors composed of one supervisor from each town who is the chairman of the town board of supervisors, one supervisor from each city ward, and one supervisor from each incorporated village, has charge of the road and bridge affairs coming under the jurisdiction of the county. The county clerk and county treasurer are respectively clerk and fiscal agent of the board. In counties containing 250,000 or more inhabitants authority is vested in a board of supervisors, one member, whose term of office is four years, being elected from each assembly district. The term of the office of members of the regular boards is in most cases one year, but any county board may by resolution decide that members shall be elected for three years.

Each county board is required to appoint a county highway commissioner or to request the State highway commission to designate an acting highway commissioner. He is the executive officer of the board, subject to the orders of a committee appointed by the board and designated as the county "State road and bridge committee." Members may be either members of the board or merely residents of the county. In addition thereto, the chairman of the town board is ex officio member of this committee when road matters in his town are considered by the board. This committee represents the county in all road and bridge work to which the county contributes except county-aid bridges costing less than $500.



Town.—Towns are governed by a board of three supervisors elected annually, one of whom is designated on the ballot as chairman. The town clerk and the town treasurer are clerk and fiscal agent of the board. In counties containing not less than 100,000 inhabitants, the term of office of town officials is two years.

The town board appoints one or more superintendents of highways to superintend construction and repair of all roads and bridges under the jurisdiction of the board. When more than one superintendent is appointed the county is divided into suitable districts and each district is placed under the jurisdiction of a district superintendent. In towns where the highway tax is paid in labor, a town road overseer may be appointed who, under the orders of the board, exercises supervision over district superintendents. The town board has the power within statutory limits to levy taxes, issue bonds, and to enter into contracts.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The 77,270 miles of public road of Wisconsin are, for the purpose of fixing responsibility for control, construction, and maintenance, divided into four groups, namely, State trunk highways, State highways, county systems of prospective State highways, and town roads.

State trunk highways.—These comprise about 5,000 miles of road designated by the State legislature to connect all county seats and towns of 5,000 or more inhabitants. These roads are constructed under the supervision of the State highway commission with funds provided in equal amounts by the Federal Government, State, and county. The county may assess not to exceed 40 per cent of its share of cost to the town or towns benefiting by the improvement. The county is also required to expend 50 per cent of its allotment of State aid, with the accompanying local funds, on the State trunk highway system. Improved roads of this group are maintained by the county with county funds in accordance with the instructions and under the supervision of the State highway commission. Reimbursement of the total cost of maintenance, or a portion thereof, is made to the county by the State highway commission from funds derived from the proceeds of motor-vehicle license fees.

The program of construction in each county for any given year is published by November 1 of the previous year in order that the county's portion of the cost may be paid into the State treasury before construction is instituted. If a county fails to provide the amount required by law to secure its allotment for State trunk highways, the State highway commission is required to notify the secretary of State of such failure. The secretary then levies a special tax in the county, the proceeds of which are placed in the State treasury on behalf of the county and are available for construction purposes. The State highway commission executes surveys, provides plans and specifications, and supervises construction. The construction may be done by force account, convict labor with the permission and under rules and regulations of the State board of control, or by contract. When by contract let by the State highway commission, the manner of letting, making payments, and final acceptance is decided by the commission.

State highways.—These comprise about 5,070 miles of public road originally included in the county system of prospective State highways, and which have been improved at State and local expense under supervision of the State highway commission, and are maintained by the county with county funds under the instructions and supervision of the State highway commission.

The county systems of prospective State highways.—These comprise about 20,000 miles of which 5,070 miles have been improved as above described while approximately 15,000 miles remain unimproved. These roads may be designated by the county boards with the approval of the State highway commission for improvement with State and local funds. The construction of such roads is administered by the county board through its State Road and Bridge Committee and County Highway Commissioner, in accordance with plans and specifications approved by the State highway commission. On request of the county highway officials the highway commission will delegate suitable officials to take charge of construction. Inspection may be made any time during the progress of the work when administered by local officials by a representative of the State highway commission. The work may be done by paid labor or by contract let by the board through its committee. The approval of the State Highway commission is required to all contracts let for roads of this group. Partial payments may be made by the county treasurer from time to time when recommended by the engineer in charge of the work and ordered by the county commissioner of highways. A copy of the approved estimate submitted by the engineer in charge must accompany the warrant drawn on the treasury.

When at least 50 per cent of the work has been completed to the satisfaction of the State highway engineer, he then orders the State treasurer to transfer to the county treasurer the State's portion of the cost of the work. The State's portion may not in any case exceed 40 per cent of the total cost when the remainder is borne by the county, or 33⅓ per cent of the total cost when the county and towns share the remainder of the cost. Final payment may not be made to the contractor until the work has been accepted by the State highway commission, and such acceptance in writing has been filed with the county commissioner of highways, and the town clerk. When the improvement has been completed the road becomes a part of the system classed as State highways, and is maintained by the county. Unsurfaced graded roads of this group are also maintained by the county in accordance with general instructions and under the supervision of the State highway commission.

Town roads.—These comprise all other public roads in the State. They are controlled and administered by the town boards of supervisors with local funds. The county board is required to allot to each town a portion of the county's share of the State-aid allotment based on the assessed valuation of the various towns, to levy a county tax of at least equal amount, and to levy against the town a tax not more than the county tax nor less than the State money allotted. The combined fund thus at the disposal of the town must be expended on the county system of prospective State highways and the location of the improvement is designated by the county board which also determines the character of the improvement. Bridges may be built on the same terms as roads.

REVENUES.

State.—Motor vehicle fees collected after July 1, 1917, are distributed as follows:

1. After the cost of collection has been deducted, one-fourth of the net proceeds is returned to the county in proportion to the amounts paid in by the residents thereof for the maintenance of the county systems of prospective State highways.

2. There is set aside from the remaining three-fourths a sum not to exceed $80,000 for the use of the State highway commission in administering the State trunk highway law.

3. There is then set aside an amount sufficient to pay the State's share of Federal aid construction.

4. The remainder is then allotted for maintenance of the State trunk highway system, and is distributed among the counties in the ratio that their trunk line highway mileage bears to the total mileage of the system.

It is estimated that for administration, the amount available to meet Federal aid construction and for trunk highway maintenance during the fiscal year ending June 30, 1918, will be $1,500,000.

An annual appropriation of $785,000 for the fiscal years 1917 and 1919 has been made by the legislature for allotment to the counties for State-aid construction. The allotments are made in the ratio that the assessed valuation of each county bears to the total assessed valuation of the State.

An annual appropriation of $65,000 has been made to defray the expense of operation of the State highway department in the administration of the State-aid law.

Thus the State funds expended by or under the supervision of the State highway department, exclusive of local contributions, will amount to approximately $2,350,000 per annum.

County.—One-fourth of the net proceeds of the motor vehicle license fees collected from each county is returned thereto as a fund to be applied to maintenance of roads on the county system of prospective State highways. The counties are required also to maintain portions of the State trunk highway system within their limits, and when this is done in a manner satisfactorily to the State highway commission, the county is entitled to receive its share of the portion of the proceeds of motor vehicle license fees devoted by law for this purpose.

Each county is required by law to provide the amounts necessary to carry out the Federal aid and State aid construction contemplated within its limits. To receive its allotment of Federal aid money a county must provide a sum at least equal to one-half the joint proceeds of the Federal and State money. One-half of each county's allotment from the State aid fund must be expended on the State trunk highway system at points designated by the county board together with an amount at least one and one-half times as great to be provided by the county. The remaining one-half of the county's allotment of State aid is required to be distributed among the towns, villages and cities in the county unbenefited by an improvement on the State trunk highway system during the same year in proportion to their assessed valuations. The county is required to provide an amount at least equal to the allotment of State aid and to assess against the town, village or city a tax in an amount not less than the State aid allotted and not greater than the county aid allotted.

Town.—A poll tax of $1.50 per year is levied on all male citizens not otherwise exempt between the ages of 21 and 50. A property tax is levied at the rate of not less than 1 nor more than 7 mills on each dollar of assessed valuation. This may be increased by a majority vote at the annual town meeting by a levy not exceeding 10 mills on each dollar of assessed valuation. The total amount so raised is limited by statute in accordance with the population of the town and may be used either for road or bridge construction. Special bridge taxes not exceeding a total of $300 per annum may be levied each year by a unanimous vote of the board of supervisors. The towns are entitled to receive county aid in proportion specified by law to aid in the construction of all bridges costing more than $200 each. Special highway taxes may be levied in a similar manner to produce not more than $600 in any one year whenever the proceeds of the existing taxes are not sufficient to carry out the work deemed advisable or necessary.

BONDS.

Bonds may be issued in a manner prescribed by law by counties and towns for road improvement purposes.

Any county board may determine to issue nontaxable, semiannual interest payment coupon bonds running not more than 20 years to an amount not to exceed one-fifth of 1 per cent of the assessed valuation of the county. The total amount of these bonds outstanding at any one time shall not exceed 1 per cent of the assessed valuation of the county. These bonds shall be in a form approved by the State highway commission.

If it is desired to issue bonds for greater amounts than the foregoing, the issue may be submitted to the voters of the county on petition of a number of voters at least equal to 10 per cent of the number of votes cast for governor at the preceding general election, or by resolution of the county board. If the issue is submitted by resolution of the county board it may be submitted at a special election on a date named in the resolution, otherwise it must be voted on at the regular April or November elections.

Towns are authorized to bond for highway improvement by issuing bonds of the same type as those hereinbefore described for the counties. The amount of bonds outstanding at any one time can not exceed the legal limitation, nor can any bonds be issued except after submission to the voters of the town at a legally called special meeting, or at the annual town meeting previous to which the issue must be advertised. The proceeds of town bonds are not available to obtain State aid and may not be issued unless the county board shall determine to issue bonds in a like amount for the improvement of the roads contemplated to be improved by the town.

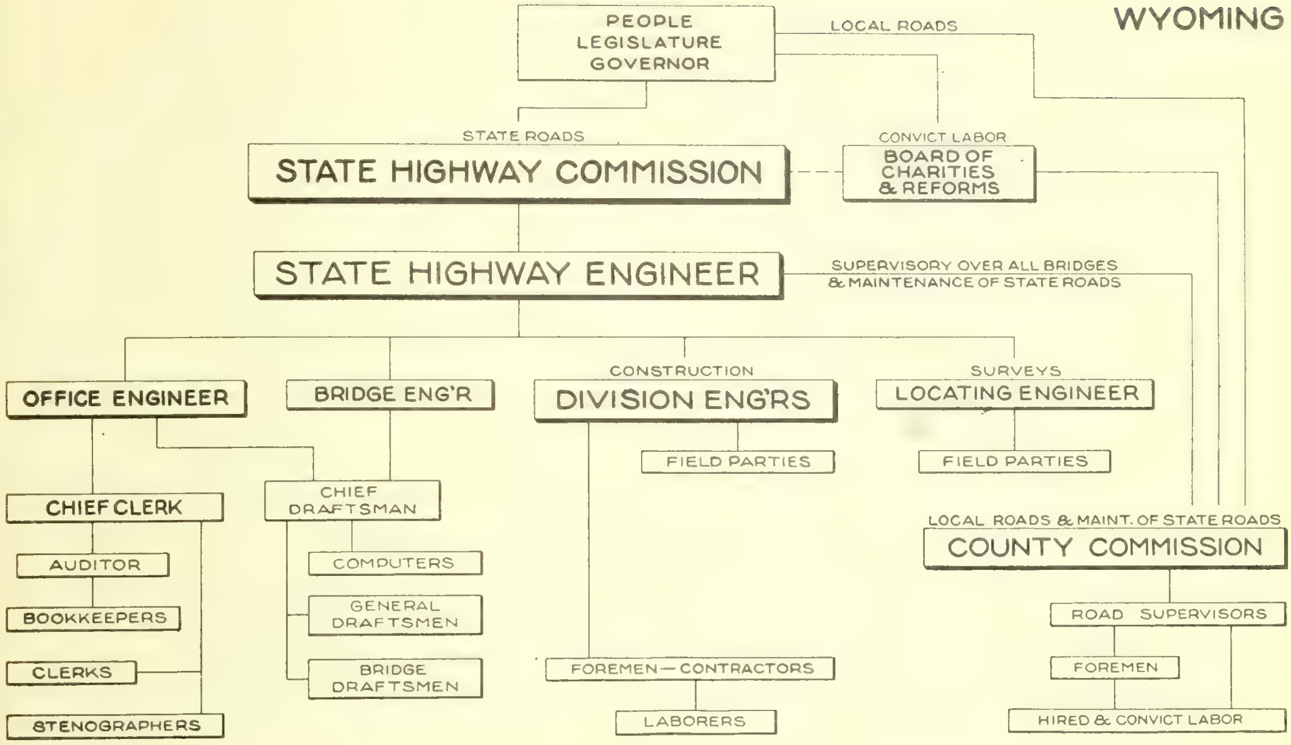
The total county and town bonds outstanding on January 1, 1915 amounted to $281,078.

WYOMING.

DEVELOPMENT.

State participation in road work in Wyoming is in its initial stage, but provision has been made to extend the State system throughout the State. The highway commission organized in 1917 has

WYOMING



supervision over all bridge work in the State and control over the construction of a system of State roads designated by the State highway commission, and which comprises about 23 per cent of the total road mileage of the State. In 1911 the legislature directed that sections of the present system of State roads be improved by means of convict labor, and the operating expense of this force was borne by the respective counties in which the work was done. Practically no permanent construction other than machine grading was accomplished.

Wyoming has an area of 97,594 square miles with a population of about 1½ persons to a square mile. As no navigable streams are found within the State and only 1,821 miles of railroad are in operation, roads are the principal means of communication. As the State does not provide an adequate amount of funds, the burden of construction necessarily falls to a great extent upon the counties. The soil, climatic, and traffic conditions are such that well graded and drained earth roads give better results than in many other States. However, at the close of 1916, 520 miles or 3½ per cent of the total mileage of the State had been hard surfaced, although the greater part of this mileage was located in the Yellowstone National Park, and had been constructed by the United States Government. The total expenditures during 1916 for road and bridge purposes by local officials amounted to $450,000, but during that year no funds whatever were expended by the State directly for road improvement.

During 1917 a total of $590,000 was expended by all road officials of the State for highway purposes.

ORGANIZATION.

The organization of the road forces of the State and the relation existing between them is shown by the diagram.

State.—The State highway commission is composed of five members appointed by the governor, from five divisions of the State, for terms of 6 years, not more than three of these members being of the same political affiliation. The commission has power to enter into contracts and agreements with the United States Government relative to construction and maintenance of roads, and to do all things required by the Secretary of Agriculture of the United States, to carry out the provisions of the Federal aid road act.

The commission may prescribe methods of cost accounting for road construction and require the various counties to adopt the same, it may publish requirements governing the issuance of certificates of competency by the State highway engineer to persons who may be employed as foremen or superintendents in charge of the construction of roads and bridges, and may prohibit counties from employing persons not possessing such certificates. The commission is empowered by State law to adopt general rules governing the letting of contracts for work under their supervision.

The State highway engineer is appointed by the commission, acts as its secretary and executive officer, and serves until removed by a vote of four members of the commission. He is required to be a competent civil engineer, experienced and skilled in road and bridge work. He employs, with the approval of the commission, such assistants and other employees as may be necessary to carry out the duties imposed on him by law and the orders of the State highway commission. In addition to his general supervisory work coming under jurisdiction of the commission he is required to furnish plans of all bridges and culverts constructed in the State which are of more than 5-foot span or which cost more than $200, and he is further required to inspect same when completed.

County.—Road and bridge control in the county is vested in a board of three county commissioners elected by the people, two members for terms of two years each and one member for four years. When they divide a county into road districts a supervisor therefor is elected at each general election for county officers. When division is not made, a county road supervisor is elected for a term of two years. Such supervisors are under the direction and control of the county board and may be removed from office by the board for due cause. The county boards have the right to levy taxes within statutory limits and to expend the funds so raised.

CLASSIFICATION, CONTROL, AND PROCEDURE.

The road mileage of Wyoming, comprising about 15,000 miles, is divided into two classes for the purpose of fixing the responsibility for construction, control, and maintenance, namely, state roads and county roads.

State roads.—These comprise about 3,100 miles designated by the legislature and which have been or will be improved by convict labor or with State or Federal and local funds. The procedure for construction is substantially as follows: County boards designate a section of State road acceptable to the State highway commission and request an allotment of funds to aid in construction, and agree to pay one-half the cost of survey and of investigation. The site of the proposed improvement is viewed by the State highway engineer or his representative, who prepares the plans, specifications, and an estimate of the total cost thereof. The county board by resolution appropriates an amount not less than one-half of the estimated total cost of construction. The State highway commission may allot State funds or request Federal aid in an amount equal to 50 per cent of the estimated total cost.

All work done under the direction of the State highway commission which has an estimated cost of $2,000 or more is let by contract except in those cases where convict labor is employed.

Convicts confined in the State penitentiary may be used on State road work under certain conditions, which are substantially as follows:

The county board of commissioners petition the State commission of prison labor for convicts. If convicts are available, the State commission of prison labor equips a gang with guards and sends them to the site of work. The county furnishes tools and materials and pays the salary of the engineer in charge of the work and the additional salary of the guard, if such is required.

When the work is done by contract due publicity is given and all bids are received and opened at the office of the State highway commission in Cheyenne. The contract is awarded to the lowest responsible bidder, conditioned on his filing a bond acceptable to the State highway commission.

Supervision of the work in progress is vested in the State highway engineer and payment from State or county funds can be made only with his approval. The county's portion of the cost is paid by the county board when the account has been approved by the State highway engineer.

Maintenance is executed by the county, subject to supervision by the State highway officials.

County roads.—These comprise all other roads in the State. They are opened, constructed, and maintained by the county boards with county funds.

REVENUES.

State.—A State-wide levy of one-fourth mill on each dollar of valuation is levied on all taxable property throughout the State, and will yield approximately $70,000 per annum.

The State highway commission sets aside from the fund representing the one-fourth mill tax a sufficient amount to pay all expenses of the commission and its employees. An amount not exceeding one-fourth of the remainder of the fund is set aside for emergency construction or repairs and for additional aid to counties. The balance of the fund is expended for the construction of roads other than those receiving Federal aid. Such roads are designated by the commission in conjunction with the respective boards of county commissioners, and financial aid is conditioned on the appropriation by the county boards of an amount equal to that provided by the State highway commission.

County.—The road and bridge funds are obtained from a tax at a rate not to exceed 3 mills on the dollar on all taxable property in the county; 80 per cent of the auto-license fees originating in the county; a poll tax of $2 per year collected from every able-bodied man not otherwise legally exempt between the ages of 21 and 50; by revenues from an inheritance tax in effect in this State; 25 per cent of the revenues collected by the United States forest reserves in the State is delivered to the treasurer of the State, who distributes it among the counties in which the reserves are located. This fund is divided between the road and school funds. No State and county bridge bonds are outstanding.

TO CHANGE OHIO ROAD DEPARTMENT.

A bill has been introduced in the Ohio Legislature to reorganize the highway department of that State. It abolishes the present nonsalaried advisory board and increases the salary of the commissioner from $4,000 a year to $6,500, provides a chief engineer at $5,000, three assistants at $4,000 each, a fiscal secretary at $4,000, and 11 district engineers at not to exceed $3,600. It would add more than $2,000,000 to the highway fund by restoring the half-mill levy, which was cut to three-tenths mill in 1914. Another bill provides for the patrol system for maintenance of improved roads.

HOUSTON-SAN ANTONIO HIGHWAY.

The first contract for the fine highway planned between Houston and San Antonio, Tex., has been let. It calls for $72,000 work in Fayette County. The estimates of the State department call for an expenditure of $341,000 right away on the project, of which $118,000 will be Federal aid.

FLORIDA ROAD BUILDING.

Florida is making plans to resume the road-construction work interrupted by the war. Bonds totaling hundreds of thousands of dollars had been sold or voted by counties before the war cut short road building. Ending October 31, 1918, the State road department had available $285,203 Federal-aid money, $1,906,105 from various counties, $139,605 from the automobile license tax for road building and repair, and a total of $1,065,445 from the automobile license tax for maintenance during 1918.

ASSESS LAND FOR ROADS.

In considering the measure now before the Oklahoma Legislature providing for a $50,000,000 bond issue for roads the house committee has voted to assess property for the first half mile back from the road at 10 cents an acre, for the next half mile 8 cents, for the next 6 cents, the next 4 cents, and the next 2 cents an acre. This is regardless of valuation. Railroad companies are to pay $15 a mile, telegraph companies $4, and telephone companies $2. This assessment is for maintenance purposes only.

REIMBURSING JERSEY COUNTIES.

The New Jersey highway commission has set aside $500,000 from the 1920 highway tax to reimburse counties which have built roads under the system of highway construction in that State. This money will be available about July 15 for Monmouth, Middlesex, and Morris Counties.

MONTANA ROAD PROJECTS.

About 30 highway projects will be ready for pushing in Montana by the time the season is right for road building. They will cost about $800,000, half of which will be furnished by the Government. Other State-aid projects are under way, and the State commission will cooperate with counties and private subscribers in the construction of the Anaconda-Hamilton road, which will shorten the distance between the two places from 150 to 72 miles.

ILLINOIS PLAN FOR TENNESSEE.

The "Illinois plan" for good roads is in operation in that State and is working well. By its provisions the State issues bonds to be paid entirely by direct tax upon auto owners. This arrangement enables the roads to pay for themselves in a few years and gives a profit paying investment to the automobilists, as the additional tax is not equal to the sum saved in gasoline and repairs. The people of Illinois voted on a $60,000,000 bond issue and they will build 4,400 miles of concrete roads connecting all towns of 2,000 and more population. The plan in Tennessee would cost $40,000,000, it is estimated. South Carolina and Georgia are agitating the adoption of this scheme for good roads and Tennessee may well consider it.—*Nashville (Tenn.) Tennessean.*

WOULD CHANGE STATE CONSTITUTION.

If the constitution of Iowa will not permit the issuance of bonds for the construction of highways, we should change the constitution at the earliest possible moment. If there is to be a comprehensive system of highways in the State, it will never come about if each county is to take its own time and way. It will result in a patchwork of good highways and poor highways.—*Storm Lake (Iowa) Pilot-Tribune.*

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ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.

Report of the Director of the Office of Public Roads for 1917.

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*45 Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.

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136. Highway Bonds.

220. Descriptive Catalogue of Road Models of Office of Public Roads.

230. Oil Mixed Portland Cement Concrete.

249 Portland Cement Concrete Pavements for Country Roads.

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386. Public Road Mileage and Revenues in the Middle Atlantic States

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389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.

390. Public Road Mileage in the United States. A summary.

393. Economic Surveys of County Highway Improvement.

407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.

414. Convict Labor for Road Work.

463. Earth, Sand-Clay, and Gravel Roads.

532. The Expansion and Contraction of Concrete and Concrete Roads.

537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.

555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials

583. Report on Experimental Convict Road Camp, Fulton County, Ga

586. Progress Reports of Experiments in Dust Prevention and Road Preservation. 1916.

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*Department supply exhausted

Dept. Bul. 660. Highway Cost Keeping.

670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.

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704. Typical Specifications for Nonbituminous Road Materials.

724. Drainage Methods and Foundations for County Roads.

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Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.

Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.

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U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

Public Roads

VOL. 1, NO. 11 WASHINGTON, D. C. MARCH, 1919

OPENING OHIO FEDERAL AID PROJECT No. 1 GOVERNOR LAYING LAST BRICK. Page 28

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

NEW ROADS OFFICIAL NAMED

Thomas H. MacDonald, of Iowa, to be in charge of Highway Work for Department of Agriculture

Thomas H. MacDonald, chief engineer of the Iowa State Highway Commission, has been appointed by the Secretary of Agriculture as engineer in immediate charge of the work under the Federal aid road act, which provides for cooperation between the States and the Federal Government in the construction and improvement of roads.

Mr. MacDonald will assume his new duties as soon as he can close up his work in Iowa. In the meantime he will continue to keep in close touch with the Federal aid road work of the department, as he has done during the past two or three months.

Steps already have been taken to expedite the resumption and extension of highway construction under the terms of the Federal law, as amended by the post office appropriation act, and nothing will be omitted to facilitate the vigorous prosecution of the work. The regulations have been carefully revised in the light of past experience and of suggestions offered by the State highway departments, the standards for plans, specifications, and estimates have been modified to meet special conditions existing in some of the States, and other changes in practices and procedure have been made, all with the definite object of speeding up the work.

Mr. MacDonald will immediately supervise and direct all the activities of the Bureau of Public Roads under the Federal aid road act, including the expenditure of the additional appropriation of $209,000,000 provided by the post office appropriation act for the extension and development of highway construction during the present and the next two fiscal years. For the time being, in the midst of the pressure incident to the resumption and extension of road work, Mr. MacDonald will devote his energies to problems arising under the Federal aid road act. It is planned that in the near future, he will formally assume the position of Director of the Bureau of Public Roads, made vacant by the death of Logan Waller Page.

Mr. MacDonald was graduated from the Iowa State College in the civil engineering course and was employed by the Chicago Great Western Railroad for a time on track work. In 1904 he became assistant professor of civil engineering at the Iowa State College and was placed in charge of road investigation work. In 1906 he was appointed highway engineer with the first highway commission in Iowa and held this position until 1913, when he was made chief engineer of the present State highway commission. He is also supervisor of State roads, having charge of all highways and streets adjoining or upon State farms, State institutions, and the State capitol at Des Moines. He is a member of the executive committee of the American Association of State Highway Officials.

Mr. MacDonald's broad knowledge of and wide experience in highway construction matters peculiarly qualify him for the very important task of directing the activities of the Federal Government under the road act, in cooperation with the State highway commissions of the various States, and of supervising the expenditure of the large sums that are now available for this purpose.

THE ENGINEER IN ROAD WORK

By RODMAN WILEY, Commissioner of Public Roads of Kentucky

WHEN one speaks of an engineer he does not necessarily mean a college graduate. Of course, it is very desirable to be a graduate from a recognized school of engineering, as that forms the basis upon which to build with experience. Neither do we mean that a man is an engineer simply because he is qualified to run a transit or level or has had a few years' experience with some engineering corps. Such an idea either in the mind of the man himself, or the people in general, is an injustice to the engineering profession.

It makes no difference what branch of engineering a man may decide to follow, he will find that it takes a great deal of study, years of training and experience, and plenty of common sense before he the A B C of engineering. In addition he must know how to meet and deal with the public and how to handle men. He must possess more ready information than most any class of professional men.

One of the best definitions of engineering according to my judgment is "science applied with common sense."

One of the most prominent engineers in this country has said that a man to be a successful engineer must have 75 per cent common sense, 15 per cent chance to display it, and 10 per cent education. After all, a man to be successful in most any line of work must have a good stock of common sense.

FORERUNNER OF CIVILIZATION.

Were we to analyze intelligently any work that has been done or is being done, we would discover that the engineer's part is not the most insignificant. He has made possible practically everything that is of use to man. As a matter of fact, the engineer is the forerunner of civilization, it might be said, the indispensable sentinel of progress.

On October 18, 1917, there appeared the following masterful editorial in the Canadian Engineer:

> Every industry depends directly upon the engineer. There are few points of life where his work has not effected big alterations. Tolerant he must be to human weakness, efficient he must be, for in few other fields of effort is the elimination of the unfit more rigorously practiced. His training is applied science and his practice demands large common sense.
>
> The engineer is one of the pivots of modern civilization; therefore he should be more in evidence as a public man. He is well fitted to carry forward the lessons of practical experience in the realm of national affairs.

In the financial end, engineers are oftentimes called upon to make an examination of the road needs of a community, the possible resources, and to report to the constituted authorities the amount of money needed and the best method of securing it; at other times they advise with the proper authorities to see if their program is sound from a financial standpoint, just the same as engineers are called upon to report to bankers and brokers on the soundness of investments in other lines of work. To-day very few investments of any size are made unless the proposition has the approval of some well-known engineer in whom the investors have implicit confidence.

MISTAKES IN LOCATION.

Every one has seen on numerous occasions the mistakes that have been made by viewers in locating roads. It must be remembered that wherever a road is built schoolhouses, residences, churches, and business houses will follow the development. In case the location is bad, it is most difficult and oftentimes impossible to provide any remedy, because if the location is changed all the improvements are lost, consequently the taxpayers are compelled from year to year to pay a heavy cost for maintaining an improperly located road. On the other hand, very few of you have ever seen a road located by good engineers that ever needed to be changed. France, Belgium, England, and Italy realized centuries ago that whenever any road improvement was started it should be in charge of the most competent engineers in the nation, consequently the roads in those countries have been located with such foresight, such knowledge of the development of the country, that it is almost impossible even at this time, with all our advanced ideas and new methods of travel to make any desirable changes.

The great trouble has been principally the fault of the taxpayers. They have not called for a business-like administration of the road affairs of their counties, and consequently they have not received it. A road is simply one of the systems of transportation, and its location requires as much if not more skill on the part of an engineer as the location of a railroad, because a railroad company usually has ruling grades, ruling degrees of curvature, and no departure is allowed from those standards, whereas when locating a road an engineer must have a vision. In his mind's eye he must see the country as it will grow, and as it will be years after the road is built. Consideration must be given to the finances of the county, which is usually not the case in railroad work.

CALLS FOR RARE JUDGMENT.

A railroad company might expend thousands of dollars to reduce a grade one-half per cent, to reduce the degree of a curve one or two points, but in road work an engineer adopts such grades as will insure the economical construction of the highway, provided, of course, that traffic will not be impeded. Highway location calls for rare judgment on the part of an engineer.

The grading of a road requires the same amount of skill and experience on the part of the man doing the work as does the grading of any railroad or interurban line. The same kind of machinery, the same instruments, are used for both classes of work. A railroad company never considers for one moment starting any construction work without having experienced engineers on the ground at all times to see that it is properly done; a contractor doing the work knows from bitter experience that he can not hope to make money unless he has an experienced man in charge, and I can not understand how men entrusted to build roads can figure that they can depart from the usual custom or that they can break all precedents and do something that railroad companies and contractors have found to be impossible from an economical standpoint and impracticable from all other angles.

When it comes to surfacing any road, the man in charge should have a thorough knowledge of the behavior of all local materials under different kinds of traffic and different climatic conditions, as well as to understand the method of doing the work. Experience has shown that attention to minute details is necessary if any type of road is properly built. One man can take a certain amount of stone and build a good road and another man will take the same class of stone and the same amount of stone and build an inferior road. That shows for itself that there is something in a man knowing how. However, the most important thing about the surfacing of any road is knowing the type to select. A great many men have had sufficient experience to know how to build a gravel road, a macadam road, or most any type of road that might be selected but the real engineering comes when we are trying to decide the proper type to build in certain localities. To intelligently make a decision, consideration must be given to the finances of the district, availability of materials, local materials, the kind and volume of traffic passing over the road, possible increase in traffic due to the improvement and the approximate cost of maintaining any type that is decided upon.

HUNDREDS OF MILLIONS WASTED.

Hundreds of millions of dollars have been wasted in this country by building the wrong type of road. In the central section of Kentucky we find almost invariably macadam roads; in western Kentucky gravel roads, and in most instances those types have been built without any consideration whatever being given to the traffic that has or will pass over the road during its life. To my mind, the selection of the proper type of road requires the highest type of engineering ability and before building any road it would be economical and certainly good common sense to get the advice of the foremost engineers in the country as to the most economical type.

On many of the roads in Kentucky, even at this advanced age, we find that it is impossible to transport the ordinary road machinery because the drainage structures will not carry the loads. Sometimes there are fairly good roads on which there has been installed drainage structures totally unsuited to the traffic. Again, structures of the wrong size have been built. It is not uncommon to see a 100-foot span trestle where perhaps a 4 by 4 culvert would suffice. Oftentimes there is installed a culvert pipe which is totally incapable of carrying the water. Even the determination of the proper size of any drainage structure is a high-class engineering problem.

NOTHING SHOWS BUT BIG EXPENSE.

The design of culverts and bridges is a branch of engineering that requires years of training and experience. No railroad company would consider for a moment letting one of their section foremen build a bridge or culvert according to his own ideas. On the contrary, every structure is carefully designed, carefully checked several times before it is ever allowed to be installed. The great trouble with highway work has been that almost everyone thinks they understand how to design and build drainage structures and we find to-day our highways adorned with structures which have little to commend them except the enormous prices paid by an unknowing public.

After a road is built it must be maintained, and everyone who has had any experience in road maintenance knows it should not be attempted by any but experienced men because it is one of the easiest ways known to waste money. Just what to do to a road in certain stages of deterioration is one of the most difficult things for even the most experienced engineers to determine. I have seen some men use 500 cubic yards of stone to the mile and make less showing and do less good than an experienced man would with a hundred yards of the same material.

It has always occurred to me as being peculiar that separate accounts have not been kept showing the expenditures which have been made on a road. To-day it would be impossible to go to any county in Kentucky and find the cost of a single mile of road unless that mile had been built under State supervision where cost records are accurately kept. It is part of the training of an engineer to analyze costs, to segregate costs so that they know not only the original cost of any improvement but also what it has cost from year to year; only by keeping and knowing such things can we ever be certain that we are doing economical work.

TAXPAYERS PAY FOR ALL MISTAKES.

I have endeavored to show that every phase of road building is an engineering problem and the sooner that fact is realized the sooner will the taxpayers be properly protected. But the thing I am contending for will not come over night. Men without any knowledge of the subject will be elected to office on some fake issue and will continue to build roads according to their own pet theories, many of which will be at variance with good engineering, but the taxpayers should remember that they are paying for all mistakes made.

Never before in the history of the world has mankind been so dependent upon the engineer. The late war was essentially a war of engineers; for it is they who designed the guns, the ships, the gas bombs, the depth bombs, the aeroplanes, the ammunition, built the roads, cantonments, the trenches, railroads and bridges for our armies, and the public is now beginning to recognize the truth of the saying that "when something of importance has to be done, it is necessary to call in the engineer."

Noted men have made the statement that of the $300,000,000 expended in this country on roads last year that at least one-third was wasted, and it is now time for the people to take this matter in hand and see that not a single piece of road work is attempted unless done by skilled engineers; then every cent expended on location will be a permanent investment, every fill and every cut that is made will be properly done, every bridge and every culvert built so that it will carry the loads that pass over the road. The type of surfacing used will be the most economical one, and the roads when once built will be maintained instead of being allowed to deteriorate from day to day. Every cent expended will be properly accounted for, and then and only then will the taxpayers realize a dollar's worth of work for every dollar of their money invested in roads. When such time shall come the people will be willing to pay taxes for roads, because they will see that their interests are properly safeguarded, and we will have more and better roads at a cheaper price.

TYPICAL SPECIFICATIONS

In order to meet the frequent requests for information as to what specifications will be approved by the Bureau of Public Roads for use on Federal-aid highways, typical specifications have been prepared and furnished to the district engineer for use in reviewing specifications for Federal-aid road work.

In preparing these specifications the aim has been to obtain good work by the use of well-recognized methods of general adaptability. This has quite naturally, and very properly, prevented the inclusion of specifications based on new theories or recent developments which have not as yet so proved their worth during long periods of actual use as to have caused their general acceptance. In short, these specifications are conservative. On the other hand, they represent good practice and, if followed, will insure good work.

The general clauses are written with full knowledge that local conditions and local laws will require numerous minor modifications. It is patently impossible to cover all local conditions within any reasonable space, and so no effort has been made to cover such conditions at all, it being assumed that the engineers who are responsible for the actual preparation of the specifications are familiar with the local conditions which will necessitate these minor modifications.

It should also be understood that these specifications are not, in any sense, to be taken as indicating the bureau's opinion as to the best practice under all possible conditions in the construction of the several classes of highways. It, therefore, follows that wherever those who are writing specifications desire to adopt more rigid technical requirements than those established in the typical specifications, the more rigid requirements will be accepted. It is well recognized that there are special conditions of drainage, soil, volume of traffic, etc., which may make material modifications desirable and, where such conditions prevail, the requirements of the typical specifications are not to be accepted as necessarily adequate to meet these conditions.

In brief, these specifications are submitted as typical of conservative practice and as a guide to those who desire to know what the Bureau of Public Roads will accept as satisfactory requirements in constructing Federal-aid highways under normal conditions.

BRITISH GRANT FOR ROAD WORK

The British Government has decided that, owing to high prices, lack of materials, shortage of labor, transport difficulties, and the need for much repair and reconstruction work, as well as the desirability of stimulating useful work, to make a grant of $50,000,000 to promote work on roads and bridges throughout the country. Of this grant $8,500,000 will be furnished by the road board and the balance by the national exchequer. The work most urgently needed is the strengthening and resurfacing with improved materials of important roads and bridges, with preference given to highways on which there is or likely to be a large motor traffic, especially on those which suffered deterioration during the war,

NEW REGULATIONS FOR VOUCHERS FOR ALL FEDERAL AID PROJECTS

New regulations as to the submission of vouchers for work done on Federal aid projects have recently been promulgated, the purpose being to simplify the vouchering, and at the same time keep within the accounting regulations established by the Comptroller of the Treasury, and to insure uniformity of procedure.

The question which, under the former regulations, gave the most trouble was the question of underruns and overruns, including incidentals and extras not specifically noted in the project agreement. Under the new instructions these are to be omitted from all vouchers except the final voucher. This has been done to save constant repetition of items of minor importance and to avoid the confusion which has too often resulted from an effort to make apparent underruns balance apparent overruns before the project has progressed far enough to warrant the assumption that the underruns will persist. To illustrate, it has often happened that where a project has carried both excavation and borrow, changes in the methods of construction, the alignment, or the grade, etc., have often resulted in changing the ratio existing between the excavation and the borrow. It is, of course, proper that the underruns, in a case of this kind, should be used to balance the overruns, but it has been found that, in practice, underruns which appear in one mile may be entirely wiped out in the next, so that when an adjustment was applied for on the original underrun, it often became necessary to readjust later on, because of the elimination of the underrun. To avoid cases of this kind it has been decided that overruns, underruns, and incidentals will all be adjusted on the final voucher. This procedure has the further advantage that besides avoiding constant adjustments and readjustments it makes it possible to allow the State to utilize all of the underruns to assist in paying for overruns and contingencies. This should prove to be of considerable assistance to the State, for contingencies are apt to run a good deal higher than was expected.

In the past it has been the practice of the Bureau of Public Roads to make the same retent against a State that the State makes against its contractors but, for many reasons, this has proved to be unsatisfactory. In order to assist the States as much as possible in handling their work, a uniform retent of only 5 per cent has been decided on and will be applied on future vouchers. The retent would have been eliminated entirely had it not been necessary to retain it in order to cover the differences which are constantly arising from slight variations in the theoretical pro rata. As it is, it has been reduced to the absolute minimum in an effort to carry the policy of assisting the States as much as possible to its logical limit.

The next provision of the new regulations is also promulgated with a view toward assisting the States, particularly on long projects composed of numerous sections. Under this provision underruns on one section become available in carrying overruns and contingencies on to other sections. It is thought that this provision will be of considerable value to those States which have adopted the policy of submitting long projects divided into a number of sections, and it is hoped that full use will be made of it.

The new regulations also permit of the use of an approximate pro rata on all but the final voucher. This is in the interest of simplicity. The former system of using a pro rata carried out to four or five decimal points was out of line with the known accuracy of the vouchers themselves. In the future, the pro rata will, in fact, be found by the simple process of computing the actual pro rata as a whole number and a decimal fraction and then striking off the decimal and using the whole number.

As appears in all of what has been here set down, the object of the new regulations on vouchering has been to assist the States by simplifying and liberalizing the method of securing payments of Federal aid just as much as is possible within the established rules of the Comptroller of the Treasury. These rules are, of course, binding wherever Federal funds are involved, but it is thought that the new regulations permit of a freedom of action that will prove quite satisfactory to all of those who are handling Federal Aid.

HIGHWAYS IN INDIANA.

Indiana is now ready to carry out an important program of road improvement under the recently enacted State highway commission and county unit road laws. Under the county unit law bonds for road purposes may be issued up to 2 per cent of the assessed valuation. The new State highway commission law provides for a levy of 10 cents on the $100 for the commission fund. State funds available for highway construction this year amount to about $2,000,000 and the Federal aid funds apportioned to the State to $2,163,392. If the State matches the Federal aid apportionment $15,000,000 will be spent during the next three years.

The new highway commission is to lay out a plan of State highways connecting every county seat and every town of more than 5,000 population. This will give about 32 miles to each county.

6,146,617 MOTOR VEHICLES IN U. S.

Registrations, Licenses, and Revenues in the United States During the Calendar Year 1918.

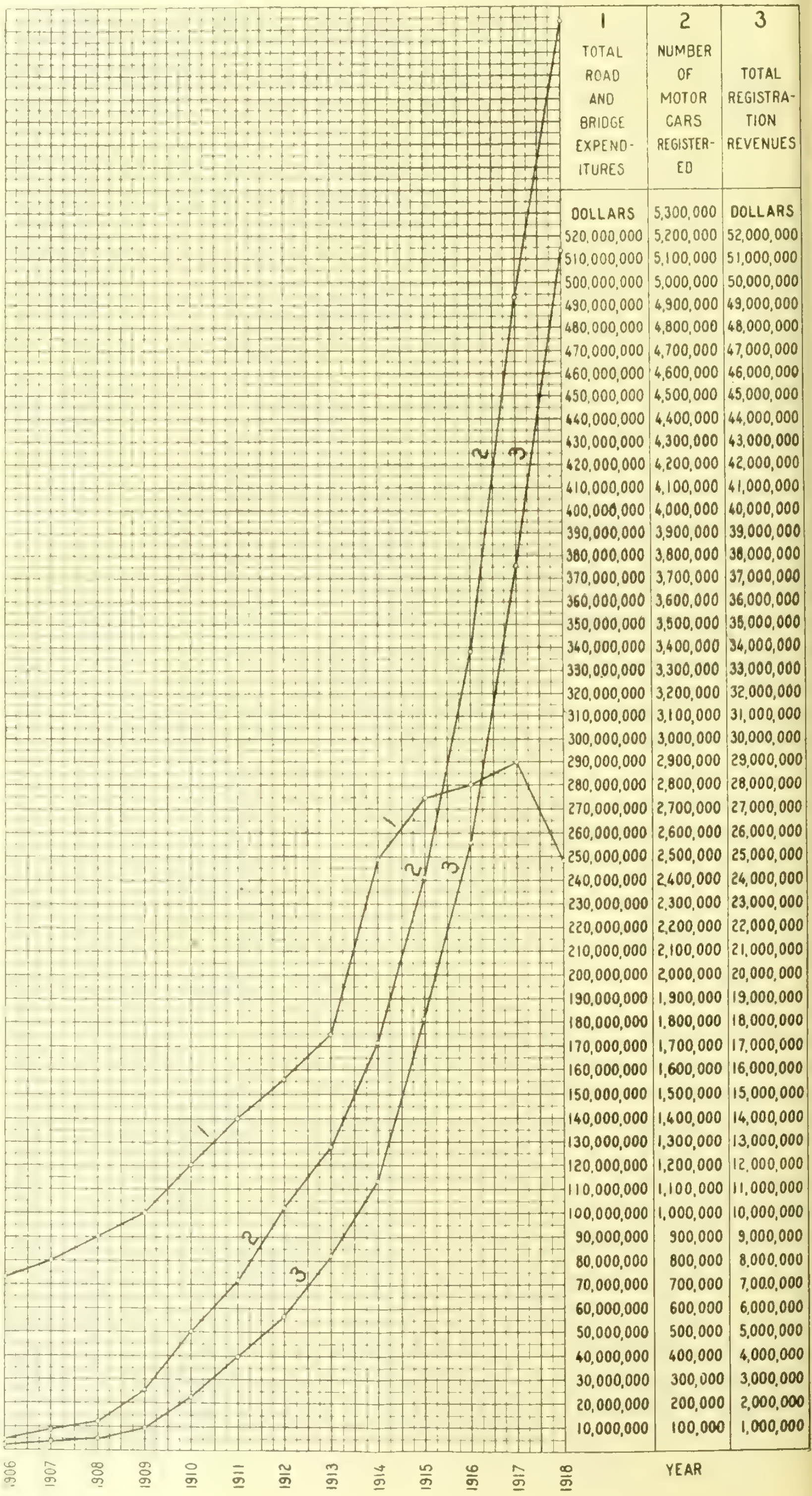
By ANDREW P. ANDERSON, Highway Engineer, Bureau of Public Roads.

A TOTAL of 6,146,617 motor cars and commercial vehicles and 240,564 motorcycles were registered in 1918 in the 48 States and the District of Columbia. The registration and license fees, including chauffeurs, operators, and dealers, amounted to a total of $51,477,416.61. These figures do not include about 107,000 automobiles and motor trucks manufactured for the Federal Government during the year 1918, which, as a rule, were not registered and paid no registration fees.

As compared with 1917, the data for 1918 represent an increase of 1,163,277, or 19 per cent, in the number of cars, and $13,976,180, or 27 per cent, in revenues. While these figures represent a striking increase in both the number of cars registered and the revenues collected, they show a considerable decline in the percentage or rate increase which existed throughout the five-year period previous to 1918. During this period the annual average increase in the number of cars over each succeeding year was 44 per cent and the increase in the amount of revenues was 45 per cent, as compared with the 19 and 27 per cent increases for the year 1918. This decrease in the rate is no doubt largely, if not entirely, due to the effect of the war.

87 PER CENT IN UNITED STATES.

There is very little definite information available as to the number of motor cars in countries other than the United States and Canada. According to the best available data and estimates, the total number of motor cars in the world amounts to about 7,000,000, of which more than 87 per cent are in the United States, nearly 4 per cent in Canada, slightly less than 1 per cent in the other countries of North and South America, and 7 per cent in Europe. About 265,000 cars are reported to be registered in Canada, in all the Provinces of which annual registrations are now in force. Probably not more than 65,000 cars are found in all of North and South



America outside of the United States and Canada. The present number of cars in Europe is not known with any degree of accuracy. Estimates based on data available for 1914 would place the total number below 500,000 or about the same as the number of motor cars at present in the State of New York.

The increase in motor-car registrations and revenues in the United States during the past dozen years represents some interesting comparisons. This is especially true in respect to the use made of the revenues. In 1906 the total registrations were approximately 48,000 cars, paying a gross revenue of about $193,000, or roughly the same as the returns from the District of Columbia for the year 1918. Furthermore, in 1906 the gross registration revenues represented less than three-tenths of 1 per cent of the total rural road and bridge expenditures for that year. In 1918 the motor-vehicle revenues represented approximately 21 per cent of the total road and bridge expenditures for that year. Furthermore, while in 1906 practically none of the motor-vehicle revenues were applied to road construction or maintenance, in 1918 nearly 91 per cent of the gross returns, or $46,935,691, were devoted to this purpose in 46 States, and of the total amount applied to road work 77 per cent, or $36,161,473, was expended more or less directly under the control or supervision of the State highway departments. The 9 per cent not applied to road work was expended very largely for plates and in carrying out the provisions of the motor-vehicle registration laws of the several States.

TABLE I.—Motor-vehicle registrations, licenses, and revenues, 1918.

State.	Automobiles.	Motor trucks and commercial vehicles.	Motorcycles.	Reregistrations or transfers.	Owners' and chauffeurs' licenses.	Manufacturers' and dealers' licenses.	Total gross motor-vehicle registration and license revenues.	Motor-vehicle revenues available for road work.		Average gross revenue return per motor car registration.	Population per motor car.	Motor cars per mile of public rural road.
								By or under State highway department.	Under direction of local authorities.			
Alabama [1]	37,874	8,297	1,180		2,455		$470,273.50	...	...	$10.18	51	0.8
Arizona	21,498	2,407	685	...	444	237	142,288.25	$142,288.25	...	5.91	11	2.0
Arkansas	41,458	(2)	...	481	638	...	410,648.50	410,648.50	...	9.80	42	.8
California	[3] 407,761	(2)	27,887	40,720	420,480	2,475	3,524,035.61	1,421.319.79	$1,421,319.79	8.64	7	6.6
Colorado	83,244	(2)	3,872	1,580	9,686	2,015	379,559.20	174,432.40	174,432.41	4.56	12	2.1
Connecticut	[4] 70,807	15,260	4,246	10,650	104,000	360	1,285,164.27	1,285,164.27	...	14.91	14	6.1
Delaware	12,955	(2)	707	889	17,060	328	232,449.00	232,449.00	...	17.94	17	3.6
District of Columbia	[5] 25,359	[6] 5,131	2,353	...	17,255	738	220,753.00	...	...	7.24	12	...
Florida	49,306	[7] 4,880	1,629	1,333	44,934	314	345,775.36	288,775.36	...	6.38	17	3.0
Georgia	99,676	5,000	1,681	...	4,762	940	331,816.19	...	305,872.07	3.17	29	1.3
Idaho	32,289	(2)	707	361	968	429	576,554.61	144,138.65	432,415.96	17.86	14	1.2
Illinois	389,620	(2)	10,834	...	45,626	3,548	2,764,330.27	2,764,330.28	...	7.09	16	4.0
Indiana	227,160	(2)	9,112	...	4,641	990	1,293,128.00	...	1,162,125.00	5.69	12	3.0
Iowa	278,313	(2)	2,529	59,797	...	2,451	2,547,595.80	[8] 2,547,595.80	...	9.15	...	2.7
Kansas	189,163	(2)	4,173	4,195	...	1,431	978,837.00	...	878,500.50	5.17	10	1.7
Kentucky	65,884	(2)	1,479	...	3,000	...	402,250.11	355,000.00	...	6.08	36	1.1
Louisiana	40,000	(2)	399	400	...	402	240,000.00	...	216,000.00	6.00	46	1.6
Maine	40,372	4,200	1,497	2,418	54,179	435	570,171.00	570,171.00	...	14.12	19	1.9
Maryland	67,839	[9] 6,827	5,351	3,474	31,096	2,034	1,189,984.25	827,203.21	...	15.94	18	4.5
Massachusetts	160,486	33,011	12,862	16,158	235,140	2,493	2,184,821.00	2,135,000.00	...	11.29	19	10.4
Michigan	235,608	26.517	7,818	13,128	25.007	845	2,875,266.32	1,479,408.48	1,395,857.84	10.97	11	3.5
Minnesota	204,458	(2)	5,021	2,749	6,253	3,985	1,076,811.00	1,076,811.00	...	5.32	11	2.2
Mississippi [10]	46,000	2,400	1,000	...	...	...	335,000.00	...	300,000.00	6.92	41	1.1
Missouri	188,040	(2)	3,980	9,385	210,020	1,660	1,394,762.19	1,234,475.03	...	7.41	13	1.9
Montana	51,053	(2)	852	931	1,470	298	350,913.50	237,720.50	79,240.17	6.87	9	1.3
Nebraska	173,374	(2)	2,900	1,765	...	2,195	536,897.00	...	480,000.00	3.09	7	2.1
Nevada	8,159	(2)	121	...	...	50	31,082.75	25,288.25	1,939.50	3.81	13	.7
New Hampshire	[11] 22,106	2,711	2,453	2,254	[12] 31,146	195	509,335.10	455,372.09	...	20.52	18	1.7
New Jersey	139,783	[13] 15,736	12,517	26,890	201,022	1,368	2,431,756.70	2,393,939.33	...	15.63	19	11.1
New Mexico	17,647	(2)	300	...	...	148	105,631.35	45,751.42	45,751.42	5.97	25	1.5
New York	365,874	[14] 93,414	28,597	...	147,756	2,252	4,945,297.50	2,563,536.81	1,445,329.09	10.76	22	5.8
North Carolina	72,313	(2)	1,333	...	...	600	394,738.67	69,079.27	276,317.07	5.46	33	1.4
North Dakota	71,678	(2)	1,659	935	...	847	471,428.77	314,285.85	157,142.92	6.44	11	1.0
Ohio	412,775	(2)	20,717	9,215	159	3,272	2,125,425.50	1,975,425.50	...	5.15	12	4.8
Oklahoma	[15] 121,500	(2)	1,622	...	...	3,116	1,102,379.77	992,141.79	...	9.07	18	1.1
Oregon	63,324	(2)	3,501	9,451	3,128	451	461,422.00	419,922.00	...	7.28	13	1.7
Pennsylvania	363,001	[16] 31,185	26,621	24,734	204,473	7,887	4,048,185.50	4,048,185.50	...	10.05	22	4.3
Rhode Island	29,178	[17] 7,040	1,464	3,179	38,467	140	385,608.00	385,608.00	...	10.95	18	16.2
South Carolina	55,492	(2)	1,147	1,368	...	2,930	300,216.71	60,043.34	240,173.37	5.41	30	1.3
South Dakota	90,521	(2)	1,323	2,437	...	1,118	282,742.00	...	240,330.70	3.21	8	.9
Tennessee [10]	63,000	(2)	800	...	...	450	390,000.00	351,000.00	...	6.19	36	1.4
Texas	251,118	(2)	2,496	24,514	22,738	4,002	2,039,588.77	806,349.49	1,019,794.38	8.12	18	1.9
Utah	27,204	5,069	1,298	500	1,474	175	229,203.24	215,598.54	...	7.10	14	3.6
Vermont	20,681	1,872	734	1,798	27,980	158	398,855.64	368,855.64	...	17.68	16	1.5
Virginia	72,228	(2)	2,414	...	4,760	386	684,636.35	650,431.63	...	9.48	31	1.3
Washington	[18] 101,161	16.117	6,317	11,619	...	678	875,391.25	790,996.25	...	7.46	13	2.7
West Virginia [19]	38,750	(2)	825	...	3,840	569	447,705.11	447,705.11	...	11.55	36	1.2
Wisconsin	189,436	6,817	7,238	...	...	1,500	2,076,701.00	1,505,025.75	501,675.25	10.58	13	2.5
Wyoming	16,200	(2)	313	...	...	167	80,000.00	...	...	4.94	11	1.1
Total	5,852,726	[20] 293,891	[20] 240,564	[20] 287,311	[20] 1,926,127	[20] 63,065	51,477,416.61	36,161,473.08	10,774,217.44	8.37	16	2.5

[1] Fiscal year ending Sept. 30.

[2] Included under automobiles.

[3] Does not include 701 trailers.

[4] Does not include 3,441 public service registrations.

[5] Does not include 3,222 free permits nor 10,252 nonresident registrations.

[6] Does not include 1,684 nonresident vehicles.

[7] Does not include 151 trailers and commercial cars.

[8] Devoted to State and local road work and payment of registration expenses.

[9] Does not include 73 tractors nor 3,127 motor busses and commercial trucks.

[10] Approximate.

[11] Does not include 1,446 nonresident registrations.

[12] Does not include 1,447 nonresident chauffeurs and owners.

[13] Includes only cars weighing more than 4,000 pounds.

[14] Includes 18,105 omnibuses, but does not include 2,218 trailers.

[15] Includes trucks but does not include 2,674 traction engines.

[16] Does not include 3,103 traction engines and 1,284 trailers.

[17] Does not include 29 tractor registrations.

[18] Does not include 976 exempt cars.

[19] For period July–December, 1918.

[20] Partial total.

The approximate relations and rates of variation of the three factors, total rural road and bridge expenditures, motor-vehicle registration and license revenues, and the number of motor-car registrations from 1903 to 1918, inclusive, are shown graphically in the accompanying chart, page 8.

MOST OF REVENUE FOR ROAD WORK.

On January 1, 1919, every State but Minnesota had made provision for some definite form of annual State registration. In Minnesota the registrations are for a period of three years, beginning January 1, 1918. Consequently, unless the laws are amended, only new cars will pay a registration fee during 1919, which fee will cover the years 1919 and 1920.

At present all or a major portion of the motor-vehicle revenues are applied to road work in all of the States except Alabama, Wyoming, and the District of Columbia. In Alabama the revenues go to the State, county, and city general funds. In Wyoming they are returned to the counties without any stipulation that they shall be used for road work; while in the District of Columbia they are paid into the general fund.

For a number of years a general tendency toward devoting an ever increasing portion of the net motor-vehicle revenues to road work under the control and direct supervision of the State highway departments has been very noticeable. Thus, while the total increase in the motor-vehicle revenues for 1918 over those of 1917 was 27 per cent, the increase in the amount devoted to road work under the State highway departments over that of 1917 was about 35 per cent. This increase in the State-controlled revenues devoted to road work caused a decrease of nearly 10 per cent in the revenues placed under the supervision of local authorities.

TABLE II.—Motor-car registrations and gross motor-vehicle revenues, 1914 to 1918.

	Motor-car registration.[1]					Total gross revenues.				
	1914	1915	1916	1917	1918	1914	1915	1916	1917	1918
Alabama	8,672	11,634	21,636	32,873	46,171	$113,202	$180,744	$203,655	$217,700	$470,274
Arizona	5,040	7,753	12,300	19,890	23,905	34,077	45,579	73,000	117,643	142,288
Arkansas	5,642	8,021	15,000	28,693	41,458	56,420	80,551	150,000	205,176	410,649
California	123,504	163,797	232,440	306,916	407,761	1,338,785	2,027,432	2,192,699	2,846,030	3,524,036
Colorado	17,756	28,894	43,296	87,460	83,244	80,047	120,801	197,795	296,808	379,559
Connecticut	27,786	41,121	56,048	74,645	86,067	406,623	536,970	768,728	1,080,757	1,285,164
Delaware	3,050	5,052	7,102	10,700	12,955	35,672	55,596	85,249	133,883	232,449
District of Columbia	4,833	8,009	13,118	15,493	30,490	20,147	29,396	47,624	55,928	220,753
Florida	[2] 3,368	[2] 10,850	20,718	[3] 27,000	51,186	[4] 6,736	[3] 60,000	127,176	[3] 170,000	345,775
Georgia	20,915	25,000	46,025	70,324	104,676	104,575	125,000	154,735	229,653	331,816
Idaho	3,346	7,071	12,999	24,731	32,289	58,580	121,259	213,758	412,641	576,555
Illinois	131,140	180,832	248,429	340,292	389,620	699,725	924,906	1,236,566	1,588,835	2,764,330
Indiana	66,500	96,915	139,065	192,194	227,160	432,309	587,318	817,285	1,096,159	1,293,128
Iowa	106,087	145,109	198,587	254,462	278,313	1,040,136	1,533,054	1,776,170	2,249,655	2,547,596
Kansas	49,374	72,520	112,122	159,343	189,163	268,471	387,588	585,762	830,878	978,837
Kentucky	11,766	19,500	31,500	47,420	65,884	85,883	117,117	184,741	287,314	402,250
Louisiana	[3] 12,000	11,380	17,000	28,394	40,000	[3] 12,000	75,600	112,000	166,835	240,000
Maine	15,700	21,545	30,972	41,499	40,372	192,542	268,412	363,562	491,696	570,171
Maryland	20,213	31,047	44,245	60,943	74,666	268,231	386,565	565,302	807,395	1,189,984
Massachusetts	77,246	102,633	136,809	174,274	193,497	923,961	1,235,724	1,602,958	1,969,994	2,184,821
Michigan	76,389	114,845	160,052	247,006	262,125	(4)	373,833	1,739,344	2,471,271	2,875,266
Minnesota	67,862	93,269	[5] 46,000	[6] 54,009	204,458	132,398	[3] 160,510	82,469	100,000	1,076,811
Mississippi[3]	5,694	9,669	25,000	36,600	48,400	51,146	76,700	175,000	250,000	335,000
Missouri	54,468	76,462	103,587	147,528	188,040	235,873	323,289	439,315	617,942	1,394,762
Montana	10,200	14,540	25,105	42,749	51,053	27,000	33,120	52,768	290,936	350,914
Nebraska	16,385	59,000	101,200	148,101	173,374	34,325	[3] 183,000	311,334	451,303	536,897
Nevada	1,487	2,009	4,919	7,160	8,159	4,331	7,875	20,116	31,166	31,083
New Hampshire	9,571	13,449	17,508	22,267	24,817	185,288	257,776	344,434	425,305	509,335
New Jersey	62,961	81,848	109,414	141,918	155,519	814,536	1,062,923	1,406,806	1,923,164	2,431,757
New Mexico	3,090	5,100	8,228	14,086	17,647	19,663	29,625	47,865	80,843	105,631
New York	168,223	255,242	314,222	406,016	459,292	1,529,852	1,991,181	2,658,042	4,284,144	4,945,298
North Carolina	14,677	21,000	33,904	55,950	72,313	89,580	123,000	206,101	321,923	394,739
North Dakota	17,347	24,908	40,446	62,993	71,678	55,964	79,245	125,283	211,536	471,429
Ohio	122,504	181,332	252,431	346,772	412,775	685,457	984,622	1,286,405	1,766,427	2,125,426
Oklahoma	13,500	25,032	52,718	100,199	121,500	13,500	154,892	555,011	853,659	1,102,380
Oregon	16,447	23,585	33,917	48,632	63,324	77,592	108,881	146,232	196,787	461,422
Pennsylvania	112,854	160,137	230,578	325,153	394,186	1,185,039	1,665,276	2,325,057	3,268,025	4,048,186
Rhode Island	12,331	16,362	21,406	37,046	35,218	157,020	206,440	264,737	346,117	385,608
South Carolina[2]	14,000	15,000	[7] 25,000	38,332	55,492	14,000	15,000	10,000	113,557	300,217
South Dakota	20,929	28,724	44,271	67,158	90,521	125,000	[3] 180,000	140,746	210,592	282,742
Tennessee	[8] 19,769	[9] 7,618	[3] 30,000	48,000	63,000	39,538	[3] 34,000	186,953	322,200	390,000
Texas[2]	40,000	40,000	[7] 125,000	192,961	251,118	20,000	20,000	20,000	858,978	2,039,589
Utah	2,253	9,177	13,507	24,076	32,273	4,852	[3] 60,000	93,494	170,707	229,203
Vermont	8,475	11,499	15,671	21,633	22,553	154,267	218,480	297,992	363,541	398,856
Virginia	13,984	21,357	35,426	55,661	72,228	120,814	176,875	271,266	518,566	684,636
Washington	30,253	38,823	60,734	91,337	117,278	60,506	238,717	350,052	519,526	875,391
West Virginia	6,159	13,279	20,571	31,300	38,750	60,648	128,952	198,436	359,339	447,705
Wisconsin	53,161	79,741	115,645	158,637	196,253	293,580	431,977	615,721	861,278	2,076,701
Wyoming	2,428	3,976	7,125	12,523	16,200	12,140	19,880	35,625	57,421	80,000
Total	1,711,339	2,445,664	3,512,996	4,983,340	6,146,617	12,381,951	18,245,711	25,865,370	37,501,233	51,477,417

[1] Does not include motor cycles not dealers' and manufacturers' licenses.
[2] State registrations only.
[3] Estimated.
[4] Registration law declared unconstitutional.
[5] Cars registered during 1916; total number of cars, approximately 138,000.
[6] Cars registered, 1917.
[7] Estimated number of cars in State.
[8] Total cars registered under perennial system.
[9] Registrations 1915 only.

MOTOR REVENUES TO MEET BONDS.

In most States the motor-vehicle revenues are devoted to the maintenance and repair of the State roads or other improved highways. These States thus seem to have solved fairly well the knotty problem of how to secure sufficient funds to maintain the more important roads under the ever increasing traffic requirements. As both the traffic and the revenues increase with the number of cars, there exists a possibility of so adjusting the registration rates as to keep pace with the ever-growing maintenance charges.

Recently, however, a movement to capitalize the motor-vehicle revenues and devote these funds to road construction has been quite noticeable. This is especially true in those States which have a comparatively large number of cars and only a small mileage of improved roads. Thus, Illinois, last November, approved a bond issue of $60,000,000 for the construction of a system of State roads. The interest and principal of these bonds is to be paid entirely from the motor-vehicle revenues. There is no doubt that these revenues will prove sufficient for this purpose. The main question which remains is whether or not a satisfactory source of maintenance revenues can be secured so as to prevent these roads, when constructed, from deteriorating.

CAR DISTRIBUTION NOT UNIFORM.

The total road mileage of the United States outside incorporated towns and cities is about 2,456,000 miles. With a total registration of 6,146,617 motor vehicles there was, therefore, an average of 2.5 motor cars for every mile of public road in the United States. The distribution of cars among the several States, however, is far from uniform. Thus, Nevada has but 2 cars to every 3 miles of road, while Rhode Island has 16 cars to each mile of rural road. Furthermore, while there was an average of 1 motor car registration for every 16 persons in the United States, in the States of California and Nebraska there was 1 car for every 7 persons, and 1 car for every 8 persons in Iowa and South Dakota, but only 1 car for every 51 persons in Alabama, every 46 in Louisiana, or every 42 persons in Arkansas.

At the beginning of 1919 there were still 22 States in which motor trucks were registered at the same rate as pleasure cars. Recent years, however, have shown quite a general tendency to increase the fees required for heavy motor trucks. This increase usually is based on the weight of the truck, its carrying capacity, or a combination of its carrying capacity and its horsepower. However, there is as yet no evidence of any well defined general goal towards which this movement is tending. Some States are placing a definite maximum weight which may not be exceeded except in very special cases; others are evidently relying on discouraging or limiting the use of very heavy trucks by making the registration fees so large as to practically prevent the realization of any profit; while still other States are making no serious efforts except to limit the weight of the wheel loads per inch width of tire. The term, motor truck and commercial vehicle, moreover, is very definite. In some States the term commercial vehicle as used includes all trucks while in others only those vehicles used for hire are classed as commercial.

FEE SYSTEM COMPLICATED.

The amount of fees collected per car for either pleasure or commercial vehicles is as yet far from uniform and is still further complicated by the widely varying requirements for the registration or licensing of chauffeurs, owners, operators, dealers, etc. Thus, if the total gross registration and license revenues be used as a basis of revenue, and the total automobile trucks and vehicles as a basis for motor cars, it is found that for the entire United States the average fee per car was $8.37. On the same basis the State of New Hampshire received in 1918 a gross revenue of $20.52 for each motor car, while Minnesota received only about $1.75 annually for each car, as the registration in that State is for a three-year period.

In most States motor cars are taxed as personal property in addition to the required registration fees. In Delaware, Idaho, Iowa, Michigan, New York, North Dakota, Oklahoma, South Carolina, Pennsylvania, and Vermont the registration fees are in lieu of all other taxes. Therefore, in making any comparisons in fees as between the several States, this fact should be borne in mind.

TABLES FURNISH INDEX.

The registration of automobiles, motor trucks, commercial vehicles, chauffeurs, and operators, dealers and manufacturers, as well as the total gross registration revenues and the amount that is available for State road work, either by the State highway departments or under their supervision, for the year 1918 are given in Table 1. The number of registrations in this table do not necessarily indicate the exact number of motor vehicles of any one or of all of the several classes in actual use or existence in the several States, except so far as the laws of the several States require and enforce an annual registration under these classifications. However, as all of the States now, with the exception of Minnesota, require an annual State registration, these figures should furnish a very definite index of the total number of cars in each State. Many States make no distinction so far as the registration laws are concerned between pleasure cars and commercial vehicles. Consequently, the column headed "Motor trucks and commercial vehicles" does not show the total number of such vehicles except in some States. Reference to the principal requirements in the registration of motor vehicles in Table 4 will serve to make clear what the data in Table 1 represents.

Table 2 gives a comparison of the motor car registrations and total revenues for the years 1914 to 1918, inclusive. For further information in regard to registrations and revenues previous to 1913 the reader is referred to Office of Public Roads Bulletin No. 48, "Repair and Maintenance of Highways," pages 68 to 71.

TABLE III.—Motor-vehicle registration and license fees in force January 1, 1919.

State.	Motorcycles.	Pleasure cars.	Motor trucks and commercial cars.	Chauffeurs.	Owner operators.	Dealers and manufacturers.
Alabama	$3; with sidecar attachment, $5.	Less than 25 horsepower, $7.50; 25 to 29 horsepower, $12.50; 30 to 39 horsepower, $17.50; 40 horsepower and over, $20; electric cars, $12.50; steam cars, $15.	Same as pleasure cars, except that those over 40 horsepower pay $25 each.[1]	Original, $5; renewal, $2.50.	None	$25 to $125.
Arizona	$2	25 horsepower and under, $5; 26 to 40 horsepower, $10; over 40 horsepower, $15.	Same as pleasure cars	Perpetual, $5.	do	1 vehicle of each class at pleasure-car rates.
Arkansas	None.	All motor vehicles, $10	do	$1	do	Do.
California	$2	Electric cars, $5; all others, 40 cents per horsepower; trailers, $2.	Equipped with pneumatic tires, same as pleasure cars; others pay additional less than 2 tons unloaded, $5; 2 to 3 tons, $10; 3 to 5 tons, $15; over 5 tons, $20.	Original, $2; renewal, $1.	No fee	5 cars, $25, and $2 for each additional; motorcycles, $5.
Colorado	$2	20 horsepower and under, $2.50; 21 to 40 horsepower, $5; 41 horsepower and over, $10.	Same as pleasure cars	$1	None	5 cars, $5 each.
Connecticut	$2	50 cents per horsepower	½ ton or less, $11; 1 ton, $15, and increasing to $200 for 8 tons, and $100 per ton for each ton additional.	License, $2; examination, $2.	License, $2; examination, $2.	$50 for 5 pair of plates, additional plates, $5 per pair.[2]
Delaware	$5	$2 each 500 pounds gross weight of car and load; passengers figured at 125 pounds each.	Same as pleasure cars	$3	$3; family, $8.	$20 for 2 pairs of tags; extra tags, $10 pair.
District of Columbia	$2.	24 horsepower or less, $3; 25 to 30 horsepower, $5; over 30 horsepower, $10.	do	$2	$2	Regular rates for each car demonstrated on public roads.
Florida[3]	$2	22 horsepower or less, $5; 23 to 27 horsepower, $8; 28 to 35 horsepower, $12; above 35 horsepower, $15; any car seating more than 9 persons, $100.	1 ton or less, $10; 1 to 2 tons, $25; 2 to 4 tons, $50; more than 4 tons, $100. Trailer over 500 pounds capacity same rate as trucks.	$2	None	5 cars, $15.
Georgia	$2.	Not exceeding 25 horsepower, $3; 26 to 40 horsepower, $4; over 40 horsepower, $5; electric cars, $4.	Not exceeding 1 ton weight, $3; not exceeding 3 tons, $4; not exceeding 5 tons, $5; exceeding 5 tons, $6.	$2	do	$10 for 2 number plates and $1 for each duplicate.
Idaho	$5.	All weighing less than 2,001 pounds, $15; 2,001 to 3,000 pounds, $20; 3,001 to 4,000 pounds, $30; over 4,000 pounds, $40.	Same as pleasure cars	$2	do	$35 for one make and $25 each additional make.
Illinois[4]	$3.	10 horsepower or less, $4.50; 11 to 25 horsepower, $6; 26 to 35 horsepower, $9; 36 to 50 horsepower, $16; over 50 horsepower, $20; electric cars of 2 tons capacity or less, $10; over 2 tons capacity, $20.	do	Original, $5; renewal, $3.	do	$10 for 2 plates and $10 for each pair duplicates.
Indiana	$2.	Electric cars, $3; others, 25 horsepower or less, $5; 26 to 40 horsepower, $8; 41 to 50 horsepower, $15; over 50 horsepower, $20.	All commerical cars, $5	$2	do	$25; duplicate plates, $1 each.
Iowa	$3.	20 horsepower or less, $8; over 20 horsepower, 40 cents per horsepower; all electric and steam cars, $15 each.	Same as pleasure cars	None	do	$15.
Kansas	$2.	All cars, $5 each	do	do	do	$15 for 3 sets of tags; extra tags, 50 cents each.
Kentucky	$5.	Less than 25 horsepower, $6; 25 to 50 horsepower, $11; 50 horsepower and over, $20.	½ ton or less, $11; 1 ton, $15; and increasing to $75 for 5 tons, and $50 per ton for each ton additional.	Original, $2; renewal, $1.	do	1 registration for each class at regular rates.
Louisiana	$2.	25 cents per horsepower, with a minimum fee of $5 per car.	All motor trucks, $7.50 each	None	do	1 regular registration for each make; second-hand dealers, $10.
Maine	$5.	15 horsepower or less, $5; 16 to 35 horsepower, $10; over 35 horsepower, $15.	Commercial cars, $10.	$2	$2	$25 for 5 pairs of plates; extra plates, 75 cents each.
Maryland	$5; with sidecar, $8.	60 cents per horsepower; minimum charge, $10; $1.20 per horsepower if operated for hire.	With solid tires to 3-ton capacity, $20 per ton; 4-ton, $100; 5-ton, $150; 6-ton, $300; 7-ton, $500; electrics, one-half of above rates; trailers to 1-ton capacity, $10; others, $20 per ton.	$3	$2	$25 for 2 sets of tags and $12 for each additional set. For dealers in motorcycles, 4 tags, $20; additional tags, $5 each.

[1] Cars used for transportation of passengers paying fare, 5 or less passenger capacity, $25; 6 to 9 passenger capacity, $40; 10 or more passenger capacity, $60; operating between towns or cities 10 miles or more apart, a flat fee of $40.

[2] In case of manufacturers, $25, plus $1 for each car tested on public roads.

[3] Any county or municipality may charge an additional license tax, not to exceed 50 per cent of State license tax, on motor vehicles used for hire.

[4] Both cars and trucks may be registered in municipality in which owner resides.

TABLE III.—Motor-vehicle registration and license fees in force January 1, 1919—Continued.

State.	Motorcycles.	Pleasure cars.	Motor trucks and commercial cars.	Chauffeurs.	Owner operators.	Dealers and manufacturers.
Massachusetts	$2.	Under 20 horsepower, $5, 20 to 29 horsepower, $10, 30 to 39 horsepower, $15, 40 to 49 horsepower, $20; 50 horsepower and over, $25.	Trucks under 1 ton, $5, and $3 for each additional ton.	Original, $2; renewal $1; examination, $2.	Original, $2; renewal, $1;	$10, motorcycles; $25, motor vehicles, and $5 additional for each car over 5 operated on public roads.
Michigan	(1)	Electric cars, $1 for each motor horsepower plus 25 cents for each 100 pounds of weight, others, 25 cents per horsepower plus 25 cents for each 100 pounds of weight.	Electrics, 50 cents per motor horsepower plus 25 cents for each 100 pounds of weight others, 15 cents per horsepower plus 15 cents per 100 pounds of weight.	$2	None.	$50 for 5 cars and $10 for each additional car.[2]
Minnesota	$5	All cars, $5.	Same as pleasure cars	Original, $1.50 renewal, $1.	do	$20; extra plates, $1 per set
Mississippi	State, $2; county, $2.	State, $2 county, electric cars, $4.80; others, 24 cents per horsepower.	4,400 pounds capacity or less, $6.40; over 4,400 pounds, $12.80.	None	do	Regular rates for 4 sets of plates.
Missouri	(1)	Less than 12 horsepower, $4; 12 to 23 horsepower, $6; 24 to 35 horsepower, $10; 36 to 47 horsepower, $14, 48 to 59 horsepower, $16; 60 to 71 horsepower, $20; 72 horsepower and over, $24	Same as pleasure cars	$1.50	None	$10; for each duplicate, $5
Montana	$5	23 horsepower or less, $5; 24 to 50 horsepower, $10; over 50 horsepower, $15.	One-ton capacity or less, $5; over 1 ton and less than 2, $15; over 2 tons and less than 3, $25; over 3 tons, $40.	$2	do	Cars, $50; motorcycles, $15.
Nebraska	$2	All cars, $3 each.	All $5 each	None	do	Registration for each class, $5.
Nevada	$3.	20 horsepower or less, $3; 21 to 40 horsepower, $5.50; over 40 horsepower, $8.	Same as pleasure cars	do	do	$10 for 4 number plates; $1 for each duplicate.
New Hampshire	$2.	15 horsepower or less, $10; 16 to 30 horsepower, $15; 31 to 40 horsepower, $20; 41 to 50 horsepower, $25; 51 to 60 horsepower, $30, over 60 horsepower, $40.	do	Original, $5; renewal, $1.	Original, $3; renewal, $1.	Cars, $50; motorcycles, $5.
New Jersey	$2	10 horsepower or less, $4.50, 11 to 29 horsepower, $7.50; 30 horsepower or over, $15.	With solid tires loaded weight 1 ton or less, $6, and $3 additional for each one-half ton gross weight to 2 tons, then $4 for each additional ton; trailers, $3.	$3	$3	$5 per car not to exceed 5
New Mexico	$2	Less than 12 horsepower, $2, 12 to 19 horsepower, $4; 20 to 29 horsepower, $6, 30 to 39 horsepower, $8; 40 to 49 horsepower, $10; 50 horsepower or over, $12.	Same as pleasure cars	None	None	$12.
New York	$2.50	25 horsepower or less, $5, 26 to 34 horsepower, $10; 35 to 49 horsepower, $15; 50 horsepower and more, $25.	Gross loaded weight 2 tons or less, $10, and $5 each additional ton to 14; 14 tons, $70, and $10 each additional ton.	Original, $5; renewal, $2.	$1	$15, plus $5 for each duplicate set.
North Carolina[3]	$2	26 horsepower or less, $5; 26 to 40 horsepower, $7.50; over 40 horsepower, $10.	Same as pleasure cars	None	None	$10, plus $1 for each duplicate plate.
North Dakota	$3	20 horsepower or less, $6, and 50 cents additional for each horsepower above 20	do	do	do	$15; extra plates, 50 cents per set.
Ohio	$2	Electric cars, $3; all others, $5	do	$3	do	$5 each make of motorcycle and $10 each make of automobile.
Oklahoma	(1)	50 cents per horsepower first year; second, 40 cents per horsepower; third, 30 cents per horsepower; and thereafter, 20 cents per horsepower.	do	None	do	$15 for 2 tags and $1 each for additional tags.
Oregon	$3	Electric cars, $6; others, 26 horsepower and less, $6; 27 to 36 horsepower, $10, 37 to 40 horsepower, $15; above 40 horsepower, $20.	Electric trucks, $10; others 1½ to 2 tons, $15, and $3 for each additional one-half ton up to 5 tons, over 5 tons allowed only on special permits.	$2	do	$10 for 2 tags and $2.50 for duplicate sets.
Pennsylvania	$3	Less than 20 horsepower, $5; 20 to 34 horsepower, $10; 35 to 49 horsepower, $15, 50 horsepower and above, $20.	With pneumatic tires, same as pleasure cars, others, including load, less than 2 tons, $5, 2 to 2½ tons, $10, 2½ to 5 tons, $15; 5 to 7½ tons, $20, 7½ to 12 tons, $25, trailers, including load, less than 5 tons, $3; 5 to 12 tons, $5.	$2	No fee.	$10.
Rhode Island	$2	15 horsepower or less, $5, 16 to 30 horsepower, $10, 31 to 40 horsepower, $15; over 40 horsepower, $25.	Carrying capacity 1 ton or less, $7, with $3 additional for each ton to 4 tons, and then $4 for each ton above 4 tons, over 9-ton capacity, $40 each; trailers, $10 to $30 each	$1	$1	$25 for 5 vehicles and $5 for each additional vehicle.
South Carolina	(1)	25 cents per horsepower.	Same as pleasure cars	None	None	$15 for each make
South Dakota	$2	All cars $3 each	No registration required	do	do	$5.
Tennessee	(1)	30 cents per horsepower	30 cents per horsepower plus $3 per ton carrying capacity	do	do	$10.
Texas	$3	35 cents per horsepower	Same as pleasure cars, except when used for hire	$2	do	$15; extra numbers, $1 each
Utah	$3	Electric cars, $10; others 25 horsepower and less, $5; 26 to 40 horsepower, $10 above 40 horsepower, $15.	$10	$2	do	$25, and $2 for each set of duplicate plates

[1] Same rate as pleasure cars.

[2] In case of manufacturers, motorcycles $20, including 10 number plates.

[3] Counties or municipalities may collect additional fees equal to one-half of State registration fee

TABLE III.—Motor-vehicle registration and license fees in force January 1, 1919—Continued.

State.	Motorcycles.	Pleasure cars.	Motor trucks and commercial cars.	Chauffeurs.	Owner operators.	Dealers and manufacturers.
Vermont	$4	First registration, $1 per horsepower; second, 75 cents per horsepower; third registration and thereafter, 50 cents per horsepower.	Same as pleasure cars	$3	$2	$50.
Virginia	(1)	40 cents per horsepower	..do	$2.50	None	$50.
Washington.	$2.50	25 horsepower and less, $5; 26 to 39 horsepower, $7.50; 40 horsepower and over, $10.	Automobiles and busses for hire, $1 per horsepower; motor trucks under one-half ton capacity, $5; 1 ton, $10; 2 tons, $15; 3 tons, $25; 4 tons, $35; 5 tons, $50; 6 tons, $100; 7 tons, $250.	None	....do	Cars, $25: extra plates, $5 per pair; motorcycles, $3.
West Virginia	$5	Car weighing 1 ton or less, $10, and 25 cents additional for each 100 pounds over 1 ton.	Same as pleasure cars	$3	.do	Cars, $15 per set of plates; motorcycles, $5.
Wisconsin.	$4	All cars $10 each	Capacity less than 2,100 pounds, $15; 2,100 to 5,100 pounds, $20; 5,100 pounds or more, $25.	(2)	.do	$25 for 8 plates; extra plates, $1 each.
Wyoming	$2.50.	All cars $5 each	Same as pleasure cars	None	.do	$10 for 4 plates, $1 for each additional plate.

[1] Same rate as pleasure car.

[2] Drivers of cars operating for hire may be licensed by municipality.

TABLE IV.—Administrative provisions in force January 1, 1919, affecting motor-vehicle registrations, licenses, and revenues.

State.	Registration and licenses.					Revenues from registrations and licenses.				Traffic regulations made by—
	Official or department in charge.	Renewals.		Requirements for operators' and chauffeurs' licenses.	Non-residents' exemptions.	Applied to—	Proportion expended for roads under supervision of—		Revenues from fines and penalties applied to roads.	
		Car registrations.	Operators' and chauffeurs' licenses.				State highway department.	Local road authorities.		
Alabama	State board of equalization through probate judge.	Annual, Oct. 1.	Chauffeur, annual, Oct. 1.	Chaueffeur must be 18 years old.	Reciprocity.	State, county, and city general funds.	None	None	None	Statute.
Arizona	Secretary of state	Annual, Jan. 1.	Chauffeur, perpetual.	No examination.	6 months	State road tax fund.	All of net	..do	...do	Statute and local ordinance.
Arkansas	Commissioner of state lands, highways, and improvements.	...do	Chauffeur, annual from date.	Chauffeur must be 18 years old.	Reciprocity.	State and county road fund.	One-half	One-half	One-half of penalty for delinquency.	Do.
California	Superintendent of motor-vehicle department.	.do	Chauffeur, annual. Jan. 1.	....do	3 months	State and county road work.	One-half net.	One-half net.	All, by local community.	Do.
Colorado	Secretary of state.	...do	Chauffeur, annual, Jan. 1.	No examination.	90 days	.do	.do	...do	Same as registration revenues.	Do.
Connecticut	Commissioner of motor vehicles.	...do	All operators, annual, Mar. 1.	Examination	No limit	Maintenance State roads.	All of net	None	... do	Do.
Delaware	Secretary of state.	...do	All operators, Jan. 1.	Must be 16 yrs. old; no examination.	Reciprocity.	State highway department.	All	...do	None	Do.
District of Columbia.	Automobile board.	do	All operators, perpetual.	Examination	...do	General fund	None	...do	..do	
Florida	State comptroller	...do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	Reciprocity.	State highway department and State maintenance fund.	All of net	...do	..do	Do.
Georgia	Secretary of state.	Annual, Mar. 1.	Chauffeur, annual, Mar. 1.	Must be 16 years old.	30 days	Net to State road fund for apportionment to counties.	None	All of net	..do	Do.
Idaho	State highway commission through county assessor.	Annual, Jan. 1.	Chauffeur, annual.	Chauffeur must be 18 years of age.	Reciprocity.	State highway fund.	25 per cent	75 per cent.	Same as registration revenues.	Do.
Illinois	Secretary of state.	do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	60 days	State "road fund."	All	None	All, by local community.	Do.
Indiana	.do	..do	....do	..do	.do	Net, county road work.	None	All of net	Same as registration revenues.	Do.
Iowa	.do	.do	None	Must be 15 years of age.	Reciprocity.	State and local road work.	(1)	(1)	Local road work.	Do.
Kansas	Secretary of state through county treasurer.	Annual, July 1.	.....do	Must be 14 years of age.	30 days	Net, maintenance county and township roads.	None	All of net	None	Statute and city ordinance.
Kentucky	Commissioner of motor vehicles.	Annual, Jan. 1.	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	Reciprocity.	Net to State road fund.	All of net	None	.....do	Statute and local ordinance.
Louisiana	Secretary of state.	...do	None		..do	Net to parish road work.	None	All of net	Same as registration revenues.	Local ordinance.

[1] Sufficient funds set aside to meet Federal aid, provide maintenance of highway department and expenses of registration; remainder to counties for road work.

TABLE IV.—Administrative provisions in force January 1, 1919, affecting motor-vehicle registrations, licenses, and revenues—Continued.

State.	Registration and licenses					Revenues from registrations and licenses.			Revenues from fines and penalties applied to roads.	Traffic regulations made by
	Official or department in charge.	Renewals		Requirements for operators' and chauffeurs' licenses	Nonresidents' exemptions.	Applied to	Proportion expended for roads under supervision of—			
		Car registrations.	Operators' and chauffeurs' licenses.				State highway department.	Local road authorities		
Maine	Secretary of State	Annual, Jan. 1.	All operators, annual, Jan.	Examination optional.	30 days	State road work.	All.	None	None	Statute and local ordinance.
Maryland	Commissioner of motor vehicles.	do	Owner, perpetual; chauffeur, annual.	do	Reciprocity; 3 months.	Net 20 per cent Baltimore street work; 80 per cent State road maintenance.	80 per cent of net	do	Same as registration revenues.	Do.
Massachusetts	State highway commissioner.	do	All operators, annual from date.	Chauffeur, examination.	Reciprocity.	Net 20 per cent small town roads; 80 per cent maintenance State roads.	All net.	do	do	Statute, State highway commission, and local ordinance.
Michigan	Secretary of state.	do	Chauffeur, annual, Jan. 1.	No examination.	Reciprocity to 90 days.	State and county road work.	One-half net.	One-half net.	None	Statute and local ordinance.
Minnesota	do	Triennial.	do	Chauffeur, examination.	30 days	Net, State road and bridge fund.	All net	None	do	Do.
Mississippi	State auditor and county tax collector.	1918-1920, annual, Jan. 1.	None		60 days	State revenues to general fund; county to county road work.	None	Net county revenue.	Net, same as county revenue.	Local ordinance.
Missouri	Secretary of state.	Annual, Feb. 1.	Chauffeur, annual, Feb. 1.	Must be 18 years of age; no examination.	do	State road fund.	All of net.	None	None	Statutes and local ordinance.
Montana	do	Annual, Jan. 1.	Chauffeur, annual, Jan. 1.	No examination.	No limit.	Net to State and county road work.	One-half net.	One-half net.	do	Do.
Nebraska	Secretary of state through county treasurer.	Annual, Jan. 1.	None	Must be 16 years old.	30 days	Net to county road work.	None	All net	None	Statute and local ordinance.
Nevada	Secretary of state.	do	do		do	Net to State road work.	All net	None	do	Do.
New Hampshire.	Commissioner of motor vehicles.	do	All operators, annual. Jan.	Examination, all operators	20 days	Road maintenance.	do	do	Same as registration revenues	Do.
New Jersey	do	do	do	do	Reciprocity; 15 days.	do	do	do	do	Statute and motor vehicle commission.
New Mexico	Secretary of state	do	None	Must be 14 years old.	60 days	Net State and county road work.	50 per cent net	50 per cent net.	None	Statute and local ordinance
New York	do	Annual, Feb. 1.	All operators, annual, Feb. 1.	Chauffeur, examination.	Reciprocity.	State and local road work.[1]	50 per cent gross	50 per cent gross.	Maintenance of State roads.	Statute, State highway commission, and local ordinance
North Carolina.	do	Annual, July 1.	None	Must be 16 years of age.	Reciprocity to 60 days.	Net to State road maintenance	All net	None	None	Statute and local ordinance.
North Dakota.	do	Annual, Jan. 1.	do		No limit.	Net to State and county road work.	Two-thirds of net.	One-third of net.	do	Do
Ohio	do	do	Chauffeur, annual, Jan. 1.	Chauffeur, examination.	do	Net to State road fund.	All net	None	do	Statute, State highway department, and local ordinance.
Oklahoma	Department of highways.	do	None		Reciprocity.	10 per cent appropriated for State highway department; 90 per cent county road work.	All		All	Statute and local ordinance.
Oregon	Secretary of state.	do	Chauffeur, annual, Jan. 1.	Must be 18 years of age; no examination.	30 days	Net to Federal-aid road work.	All net	None	County road fund.	Do.
Pennsylvania.	State highway department.	do	do	Affidavits as to competency.	Reciprocity.	State and State-aid road work.	All gross	do	Certain ones locally.	Do.
Rhode Island.	State board of public roads.	do	All operators, annual from date.	Examination, all operators.	Reciprocity 10 days.	Maintenance State roads.	All net	do	Same as registration revenues	State board of public roads, statute, and local ordinance
South Carolina.	State highway engineer.	Annual, Jan. 1.			30 days	Maintenance highway department and county road work.	20 per cent	80 per cent	None	Statute and local ordinance.
South Dakota	Secretary of state through county treasurer.	do	All operators, annual from date.	Must be 15 years old.	Reciprocity.	85 per cent county road work.	None	85 per cent	do	Do.

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[1] Does not apply to revenue collected within New York City, one-half of which goes to the city general fund.

TABLE IV. Administrative provisions in force January 1, 1919, affecting motor-vehicle registrations, licenses, and revenues—Continued.

State.	Registration and licenses					Revenues from registrations and licenses			Revenues from fines and penalties applied to roads.	Traffic regulations made by—
	Official or department in charge.	Renewals.		Requirements for operators' and chauffeurs' licenses.	Non-residents' exemption.	Applied to—	Proportion expended for roads under supervision of—			
		Car registrations.	Operators' and chauffeurs' licenses.				State highway department.	Local road authorities.		
Tennessee.	State department of highways through county clerk.	Annual, Jan. 1.	All operators, annual from date.		30 days	10 per cent to State highway department. 90 per cent to county road work.	All net		Same as registration revenues.	Statute and local ordinance.
Texas	State highway department through county tax collector.	do	Chauffeur, annual, Jan. 1.	Must be 18 years of age.	90 days	Net to State and county highway funds.	50 per cent	50 per cent	County road work.	Do.
Utah	Secretary of state	Annual, Mar. 1.	do	No examination.	30 days	Motor vehicle registration fund.	All net [1]	None	None	Do.
Vermont	do	Annual, Jan. 1.	All operators, annual, Jan. 1.	Examination, chauffeur.	Reciprocity.	State maintenance fund.	do	do	do	Do.
Virginia	Secretary of commonwealth	do	Chauffeur, annual, Jan. 1.	No examination.	2 periods of 7 days each	Net maintenance State aid roads.	do	do	do	Do.
Washington	Secretary of state through county auditor.	Annual, Mar. 1	None	Operators must be 15 years of age, chauffeurs 21.	90 days	Net to permanent highway fund for maintenance.	None	All net	Same as registration revenues.	Do.
West Virginia	State road commission.	Annual, July 1.	Chauffeur, annual, July 1.	Must be 14 years of age.	Reciprocity.	State road fund	All	None	None	Do.
Wisconsin	Secretary of state	Annual, Jan. 1.	None	Must be 16 years of age.[2]	Reciprocity.	Net to State highway fund and county road work.	75 per cent net.	25 per cent net.	do	Do.
Wyoming	do	do	do	Must be 15 years of age	Reciprocity to 90 days.	80 per cent to county.	None	None	do	Statute.

[1] To pay interest and sinking fund on $2,000,000 State road bond.

[2] Drivers of cars operating for hire may be licensed by municipalities.

ROAD AND BRIDGE BUILDING AND MAINTENANCE FOR 1919

In order to secure a basis for estimating the probable amount of road and bridge work which would be undertaken during the present season by the State highway departments and the local subdivisions, a questionnaire was sent by this bureau to each of the several State highway departments. Fairly complete replies have been received from 20 States. As these States are distributed fairly well over the entire area of the United States, it would seem that they would serve as a reasonable basis for estimating the probable road and bridge work which will be undertaken during the present season. These estimates indicate a total expenditure of $385,000,000 or $110,000,000 above the average expenditure of the years 1916 and 1917. The expenditures are classified as follows:

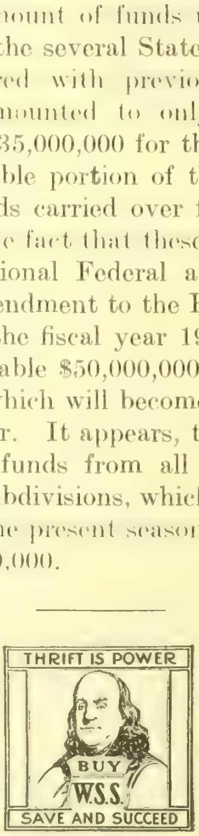
Work by or under State highway departments.

Construction under contract, 5,000 miles	$45,000,000
Construction ready for contract, 4,000 miles	30,000,000
Construction contemplated, 16,000 miles	100,000,000
Maintenance, 200,000 miles	60,000,000

Local road and bridge work by counties, townships, and districts.

Construction, 15,000 miles	$100,000,000
Maintenance, 100,000 miles	50,000,000

The most striking feature in this table is the great increase in the amount of funds under the control or supervision of the several State highway departments as compared with previous years. These funds in 1917 amounted to only $98,000,000 as compared with $235,000,000 for the present season. While a considerable portion of this increase is no doubt due to funds carried over from 1918, attention is called to the fact that these estimates do not include the additional Federal aid appropriations carried by the amendment to the Post-Office Appropriation Bill for the fiscal year 1920, which makes immediately available $50,000,000 of Federal funds and $75,000,000 which will become available July 1 of the present year. It appears, therefore, that the total amount of funds from all sources, Federal, State, and local subdivisions, which will be available for work during the present season will be, in round numbers, $500,000,000.



BUILDING AN ARIZONA PROJECT

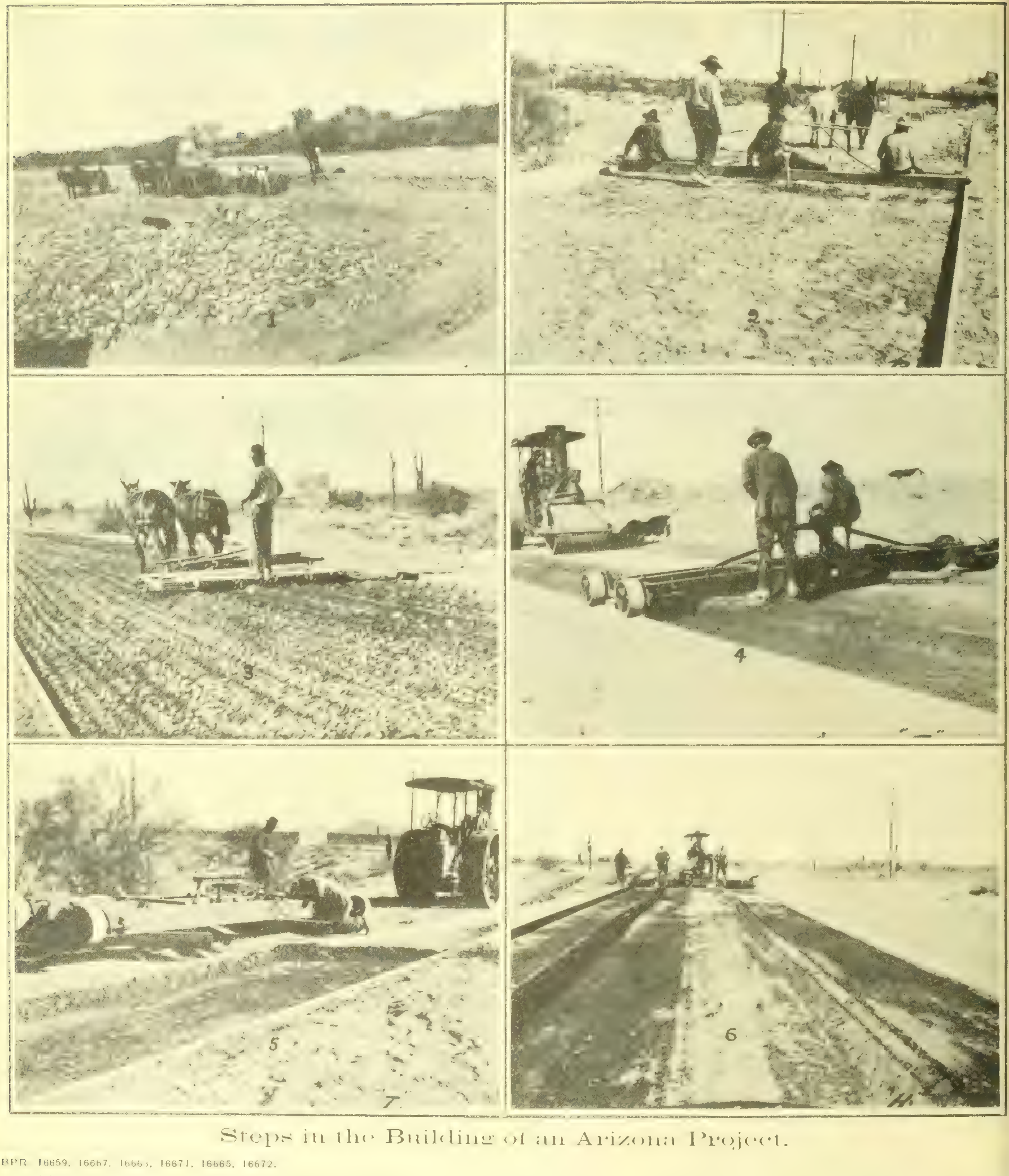
PAVEMENT CHECKED AND PONDED FOR CURING.

The Bureau of Public Roads recently received from J. W. Johnson, acting district engineer, a very interesting and illuminating set of photographs, which are herewith reproduced, covering the steps in the construction of a concrete road on Arizona Federal aid project No. 2. This project extends from Phoenix to Temple, in Maricopa County. The photographs were taken by Clyde E. Learned, highway engineer of this bureau assigned to district No. 3, and to show the various stages of construction in order. They also show the modern methods employed and the machinery used. The road was constructed of river gravel, the character of which is very well shown. The subgrade was rolled and wet after being shaped by the road drag. In order to obtain a uniform wearing surface for the concrete road the subgrade was then scarified by the use of a harrow, after which it was wet down and rolled. The final trimming was done with a trimmer, and the surplus windrows were removed with shovels.

One of the interesting photographs is that showing the method of turning the trimmer on an improvised turntable. With the final preparation of the subgrade ready for the construction of the concrete pavement, is shown the method of depositing the materials for the concrete, with the concrete mixer in the distance mixing and laying concrete. There is a close view of a mixer of the bucket and boom type, which was used on this work. It is shown in operation, delivering and dumping a bucket full of concrete on the subgrade.

The concrete surface is prepared for finishing with a screed and the Macon roller and finisher, shown in operation, was used for finishing. A close view is shown of the resulting surface after rolling. On each crossing of the roller it was advanced 2 feet. Hand-floating was done by laborers along the sides after the operation of the roller and before belting. This view also shows the portion of the pavement which has been belted and that which has been rolled.

The finishing belt was then employed with the resulting surface. On the second passage of the belt the men put the final finish to the surface by short strokes. On the third passage the men held the back edge of the belt down and slid it along without any riding movement. A rather novel split float is shown. This was used at the joints to insure an even finish on both sides of the joints, and consequently a smooth pavement. The expansion joint is seen extending above the surface of the concrete road. The concrete road is shown in its various stages of finishing. The method of curing adopted was that of curing the pavement under water.



Steps in the Building of an Arizona Project.

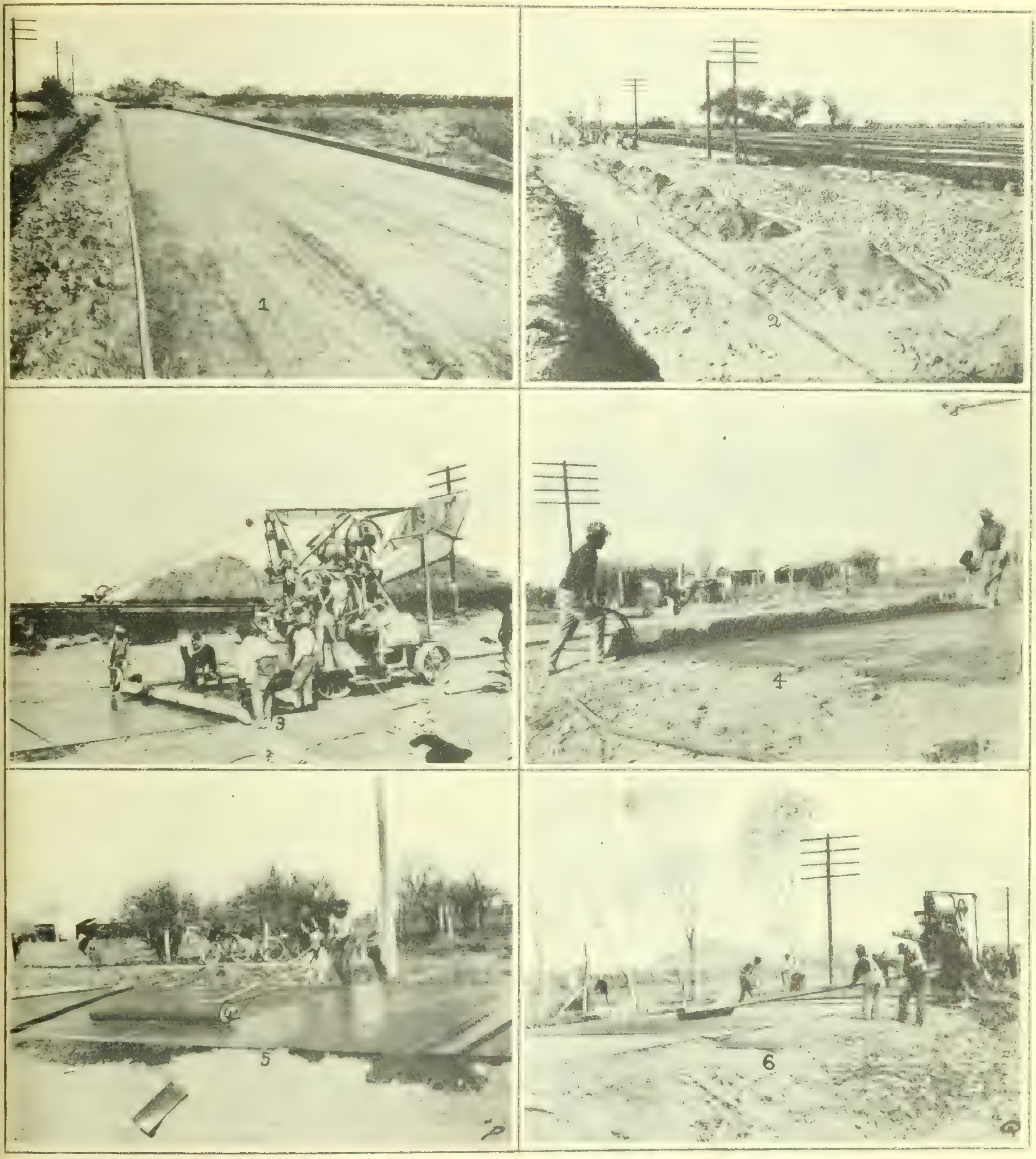
BPR 16659, 16667, 16663, 16671, 16665, 16672.

(1) PIT IN BED OF SALT RIVER FROM WHICH GRAVEL WAS TAKEN. (2) USING LOG DRAG FOR SHAPING SUBGRADE BEFORE ROLLING AND WETTING DOWN. (3) HARROWING SUBGRADE. (4) USING SUBGRADE TRIMMER. (5) TURNING SUBGRADE TRIMMER ON TURNTABLE. (6) RESULTS OF SUBGRADE TRIMMER. WINDROWS LEFT TO BE REMOVED BY SHOVELERS.

Dams were formed along the sides of the concrete pavement and transversely out of material from the ditches and shoulders frequently enough to insure the complete covering of the surface with water. This method is adaptable to roads in comparatively flat country, but would be somewhat difficult on roads of heavy grade.

BETTER TYPE ROADS IN UTAH.

Utah's State highway department has planned to make use of the increased Federal aid allowance which will come to that State under the provision made in the last Post Office appropriation act by the construction of a higher type of road instead of an



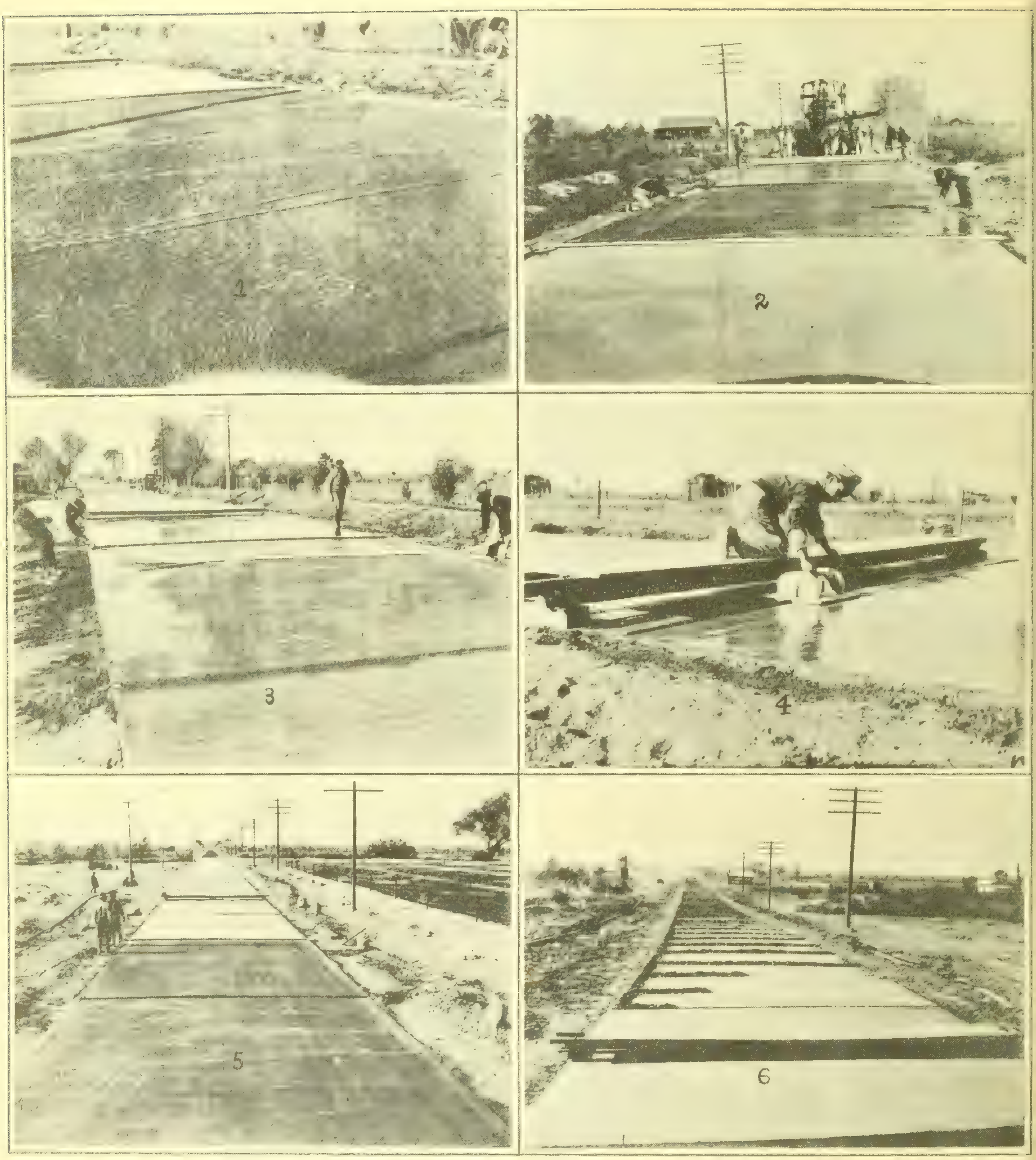
Steps in the Building of an Arizona Project.

BPR. 16669, 16670, 16668, 16674, 16661, 16655.

(1) THE FINISHED SUBGRADE. (2) WINDROWS OF MATERIAL ON SUBGRADE AHEAD OF MIXER. (3) SIDE CONCRETE MIXER SHOWING STRIKING OFF. (4) USING PLOW-HANDLE TYPE OF STRIKE BOARD. (5) USING ROLLER, EXCESS WATER BEING REMOVED IN FRONT. (6) ROLLING PAVEMENT.

increase in the number of projects. This will give not only more satisfactory roads but greatly cut down the cost of maintenance. Utah is to spend all her Federal aid allowance on the State highway system authorized by the legislature.

As originally established this system included 3,600 miles of road, which would cost the State about $1,400,000 annually for maintenance alone, if constructed of the lower type first planned. At the session of the legislature just ended an act was passed eliminating 1,200 miles from the State system and returning it to the counties as county roads to be maintained by the counties. The act provides for a tax levy by the counties for maintaining the roads.



Steps in the Building of an Arizona Project.

BPR. 16664. 16673. 16656. 16666, 16662. 16660.

(1) RESULTING SURFACE AFTER ROLLING. (2) HAND FLOATING ALONG SIDES AFTER ROLLING. (3) FIRST PASSAGE OF FINISHING BELT. (4) USING NEW TYPE OF HAND FLOAT AT JOINTS. (5) A DAY'S RUN; 530 FEET OF 18 FOOT PAVEMENT, WITH A 24-MAN GANG. (6) CHECKING OFF FOR CURING BY PONDING.

This leaves about 2,400 miles in the State highway system, to be improved by the joint use of State and Federal funds, and the increased amounts available will be used to construct the higher type road decided upon by the highway department. A tentative plan for the expenditure of the Federal aid funds available for the State, prepared by Commissioner Browning, shows the expenditure of $5,682,000 on 25 projects, having a total mileage of about 1,030. Half of the cost will be Federal aid.

The legislature at the recent session provided for the issuance of $4,000,000 of road bonds, so that ample funds will be available for the State's cooperation on Federal aid projects, both post and forest roads.

BUREAU OF PUBLIC ROADS IN THE WAR

AT THE time the United States entered the war there were on the rolls of the Bureau of Public Roads 189 male employees. Of this number, 81, or 43 per cent, had entered the military service when hostilities ceased in November. One female employee of the bureau entered the naval service as a landsman. Of the total number who entered the military service, 23, or 12 per cent, had returned to the bureau up to the close of February, 1919.

A list of those who entered the military or naval service from this bureau follows:

Name	Position with bureau.
Alderman, E. S.[1]	Highway engineer.
Angwin, Henry R.	Highway bridge engineer.
Ashby, Wallace	Barn architect.
Ayers, Quincy C.[2]	Junior drainage engineer.
Barrows, Harry H.	Senior drainage engineer.
Bartel, Frank C.	Junior drainage engineer.
Barton, Wm., jr.[1]	Computer.
Baxter, Ora G.	Senior drainage engineer.
Beebe, Lawrence E.	Assistant mechanical engineer.
Bessee, C. F.	Civil engineer draftsman.
Booth, Walter B.	Junior drainage engineer.
Boyd, George R.	Senior drainage engineer.
Boyd, Joseph R.	Laboratory assistant.
Brown, Robert A.	Superintendent road construction.
Brown, William	Clerk.
Chambers, Jos. L.	Junior drainage engineer.
Chapman, John H.	Clerk.
Chilvere, C. H.	Highway engineer.
Comfort, Willis E.[2]	Drainage engineer.
Diesem, Harry Custer	Irrigation engineer.
Dunn, Albert C.[1]	Highway engineer.
Eason, Frank G.	Senior drainage engineer.
Fairbank, H. S.[1]	Senior highway engineer.
Franks, W. G.	Accountant.
Gray, Bernard E.[1]	Engineer-economist.
Gregory, Wm. B.	Irrigation engineer.
Harrison, Robert H.	Highway engineer.
Harsch, Raymond[1]	Laboratory assistant.
Haswell, J. R.	Senior drainage engineer.
Haynes, Carlos S.[1]	Architectural draftsman.
Helmick, Dan S.[2]	Junior drainage engineer.
Hooper, Arthur L.	Junior highway engineer.
Hughes, Robert L.	Chief of survey party.
Hutchins, Wells A.	Assistant in irrigation economics.
Jeffrey, Wm. M.	Junior highway engineer.
Jones, L. A.	Drainage engineer.
Kidder, H. H.	Assistant irrigation engineer.
Kirshmer, Chas.	Drainage engineer.
Kohlmeier, J. G.	Clerk.
Lane, Albert L.	Junior drainage engineer.
Levin, Myer	Clerk.
Lewis, Richard H.[1]	Assistant chemist.
Logan, John W.[1]	Clerk.
Losh, A. R.[1]	Senior highway engineer.
Lucal, Ira D.	Clerk.
Lynch, Wm. H.[1]	Senior highway engineer.
Lyons, F. Russell	Junior highway engineer.
McCalla, W. A.	Senior highway engineer.
McCarthy, Thomas H.	Assistant irrigation engineer.
Manville, Vasco	Clerk.
Menikheim, Irvin G.	Do.
Miller, C. A.	Draftsman.
Miller, Frank S.	Clerk.
Moorefield, Chas. H.	Senior highway engineer.
Moorehead, Philip S.	Clerk.
Morris, C. C.[1]	Senior highway engineer.
Munger, Edna A.	Clerk.
Nelson, Bert F.[1]	Do.
Osterhoudt, Percy J.	Do.
Pauls, Jarl T.[1]	Highway engineer.
Pearson, Roderic	Junior highway bridge engineer.
Petrée, H. E.	Clerk.
Phillips, Clyde	Do.
Powell, Orman N.	Highway engineer.
Proudley, Charles Earl	Laboratory assistant.
Rideout, Percy A.[2]	Junior highway engineer.
Rhodes, Wm. H.	Senior highway engineer.
Rohwer, Carl	Assistant irrigation engineer.
Schuyler, J. T.	Senior highway engineer.
Skeggs, John H.	Do.
Sleight, Reuben B.	Assistant irrigation engineer.
Sloan, William G.	Drainage engineer, irrigated land.
Smith, Guy L.	Junior drainage engineer.
Stanley, Fred W.[1]	Senior irrigation engineer.
Stirton, James C.	Instrument man.
Sweetser, Charles H.	District engineer.
Tobin, James J.	Engineer economist.
Toms, Raymond E.	Senior highway engineer.
Waugh, Wm. H.	Do.
Whittle, George D.	Highway bridge engineer.
Woolf, Donald O.[1]	Laboratory assistant.

[1] Returned to the bureau prior to Feb. 28, 1919.

[2] Distinguished service cross.

The distinguished service cross was won by four men and an equal number made the supreme sacrifice. Thus the service flag of the bureau contains 77 blue and 4 gold stars.

Percy A. Rideout, who occupied the position of junior highway engineer with the bureau and who was appointed as a private and promoted to first lieutenant, was killed in action on the Verdun front, France, October 8, 1918. The distinguished-service cross was awarded to him posthumously.

H. E. Petree, who was a clerk in the bureau, went into the aircraft service as a private, was promoted to first lieutenant, and killed while making a flight back of the German lines on September 26, 1918. Official investigation discloses Lieut. Petree as one of the outstanding heroic figures of the war. French spectators of the air fight in which he met his death declare in affidavits that Petree alone engaged seven enemy scout planes back of their own lines. The investigating officer reports as follows:

> First Lieut. Harris E. Petree, pilot, One hundred and thirty-ninth Aero Squadron.—Killed September 26, 1918, near Delut (15 kilometers southeast of Longuyon), and buried in the village cemetery at Delut. Lieut. Petree, according to the village people, single-handed attacked seven German scout planes over their own field, which was near Delut and far inside the German lines. In the combat which lasted one hour, Lieut. Petree had many opportunities to escape, but he returned again and again to the attack until he finally was shot down. Lieut. Petree must have known the final outcome of the battle, but he refused to retreat. He chose to die fighting. He is the hero of the war to the village people of Delut and has made the name of an American the symbol of courage and fortitude among these simple French folk. Lieut. Petree's papers, watch, and 165 francs were taken by Kommandatur Nicolai, of Thuringia, Prussia. The German squadron was at Marville. M. Jules Vivier and his daughter, Madelaine Vivier, buried this aviator and promised to take care of his grave. We promised them that his parents would make fitting recompense.

According to Maj. Augstrom, commanding the One hundred and thirty-ninth Aero Squadron, recommendation will be made for the award of the distinguished-service cross posthumously.

Willis E. Comfort, who was employed in drainage investigations as a drainage engineer, was appointed as a lieutenant with the first expedition to be sent to France in 1917. Later he was promoted to captain and was killed in action near Soissons on July 18, 1918. The distinguished-service cross was awarded to him posthumously.

William Brown, who held the position as auditor in the district office at Portland, Oreg., was called for service in June, 1918, and died of an influenza attack at Camp Meade, Md., in October. He was a member of the 154th Depot Brigade and held the rank of private.

ROAD WORK.

Eighteen engineers were detailed by the Bureau to prepare plans and superintend the construction of roads in the 16 national army cantonments and one guard mobilization camp located as follows:

Camp Devens, Ayer, Mass.
Camp Upton, Yaphank, L. I.
Camp Dix, Wrightstown, N. J.
Camp Meade, Admiral, Md.
Camp Lee, Petersburg, Va.
Camp Jackson, Columbia, S. C.
Camp Gordon, Chamblee, Ga.
Camp Sherman, Chillicothe, Ohio
Camp Taylor, Louisville, Ky.
Camp Custer, Battle Creek, Mich.
Camp Grant, Rockford, Ill.
Camp Pike, Little Rock, Ark.
Camp Dodge, Des Moines, Iowa.
Camp Funston, Fort Riley, Kans.
Camp Travis, San Antonio, Tex.
Camp Lewis, American Lake, Wash.
Camp McClellan, Anniston, Ala.

These men were assigned in July, 1917, and the period of their assignments varied from three months to a year or more. The total construction planned and supervised by these engineers aggregated several hundred miles and included practically all of the common types of construction from sand clay to first class bituminous surfaces and concrete roads.

In addition to this work other activities in road construction not heretofore separately mentioned were as follows:

Roads were planned and their construction supervised for the Marine Corps, at Quantico, Va., and for the Bureau of Ordnance at the Edgewood Arsenal, Gunpowder, Md.

Roads were planned and their construction supervised outside of cantonments, usually from the cantonment to a city in the vicinity at the following places:

Alexandria, Va., to Camp Humphreys.
Alexandria, La., to Camp Beauregard.
Little Rock, Ark., to Camp Pike.
Columbia, S. C., to Camp Jackson.
Spartanburg, S. C., to Camp Wadsworth.
Greenville, S. C., to Camp Sevier.
Petersburg, Va., to Camp Lee.
Anniston, Ala., to Camp McClellan.

Several of the above projects were carried out in cooperation between the Federal Government and the State highway departments under the Federal aid road act.

One engineer was loaned to the United States Housing Corporation as consulting engineer on roads and streets necessary in connection with housing developments. This assignment was made in July, 1918, and the engineer gave his entire time to the work until shortly after hostilities ceased.

One highway engineer was detailed to assist the Emergency Fleet Corporation in planning roads and streets in connection with shipyard developments. He gave his entire time to this work from March 5, 1918, until shortly after the cessation of hostilities.

MAP WORK.

Complete and detailed highway maps were made, utilizing as far as practicable topographic sheets of the United States Geological Survey, covering all of Maryland east of the meridian passing through Washington, all of the coast counties of New Jersey, and all of Florida south of Jacksonville. These maps were delivered to the Corps of Engineers. In addition to these detailed highway maps, the principal highways in a zone extending from Boston to Newport News, through New York and Washington, were plotted on topographic sheets for the use of the Geological Survey in the preparation of aeroplane maps. Detailed route maps were prepared covering the Army truck route from Detroit to Baltimore, this work being done in cooperation with the United States Geological Survey and the Corps of Engineers.

DEVICE FOR TESTING EXPLOSIVES.

At the request of the Frankford Arsenal, Philadelphia, this bureau worked on a device for testing the power of explosives with the idea of obtaining an autographic record of the force and speed of the explosive.

PAGE IMPACT MACHINE.

Our large Page impact machine was borrowed by the American University for research work in connection with high explosives. At the present time impact machines of the type employed by this bureau are now being used in practically all of the arsenals throughout the country in their routine investigations of explosive materials.

COOPERATION WITH THE U. S. SHIPPING BOARD.

In cooperation with the concrete ship department of the Shipping Board, the testing laboratory of this bureau was requested to make several series of tests in order to obtain desired information looking to the safer design of reinforced concrete ships. The tests are described as follows:

Bond tests.—In view of the uncertainty of the protection of the steel by the concrete against the action of salt water, tests were made with bars protected with various kinds of paint coatings and metal coatings to determine (*a*) the protection offered by these coatings against corrosion, and (*b*) the effect of the coatings on the bond strength. Some 24 coatings were tested, involving about 250 specimens.

Shear tests.—In the design of a concrete ship the shear stresses are very high, and in order to use as little steel and concrete as possible it was necessary to use a very much higher unit stress in shear than in ordinary reinforced concrete construction. As no test results were available to indicate what would be a safe unit stress to use with the exceedingly rich mixture of concrete, it was necessary to make a number of beam tests to determine this point. A series of tests made at this bureau involved 12 beams in span length from about 5 feet to 10 feet. The materials were supplied by the Shipping Board.

Pouring tests.—Because of the extremely thin walls containing a large percentage of reinforcing steel, it was necessary to determine how best to pour the concrete so that it would entirely surround the steel and form smooth surfaces and yet be of dry enough consistency to produce the densest possible concrete. A specimen resembling the shell of a concrete vessel was made up and concrete was poured into the form and the form rapidly vibrated by hammering the sides. The forms were later stripped off and the specimen observed. The first method of pouring was a complete success and no further experiments were necessary.

Concrete bulkhead specimens.—Assistance was given to the Bureau of Standards in the pouring of a large reinforced concrete specimen designed to resemble a concrete bulkhead for use in producing water-tight compartments in steel vessels. This specimen was 18 feet high and 6 feet wide. During the pouring, measurements were taken of the pressure exerted by the concrete against the forms, using the soil pressure cells designed in this bureau.

Pressure of concrete against forces.—This series of tests was started in order to determine the pressures exerted by concrete poured so as to fill the forms at different rates. This information is useful in facilitating the economical design of the wooden forms.

Bonding of new concrete to old concrete.—There are many places in reinforced concrete ships where the concrete can not be poured continuously, but where it is necessary to join the old concrete to the newly poured concrete with as strong a bond as possible. A number of different methods for obtaining a strong bond were investigated.

Manufacture of strain gauges.—In connection with tests made for the Shipping Board at other laboratories, it was necessary to have instruments that would register exceedingly minute changes in length. At the request of the Shipping Board, this Bureau made three such test instruments after designs furnished by the Shipping Board. The Invar steel for the sides of these instruments was furnished by the Shipping Board, as were also the Amos dials. These instruments are proving very satisfactory.

UNITED STATES HIGHWAYS COUNCIL.

Origin and organization.—In the last week in May, 1918, the Secretary of Agriculture wrote to the Secretary of War, the Director General of Railroads, the Fuel Administrator, and the chairman of the War Industries Board, suggesting that each designate a representative to serve jointly with a representative of the Department of Agriculture in the handling of street and highway problems during the period of the war. In response to the Secretary's suggestions, representatives were designated to serve for the War Department, the Railroad Administration, the Fuel Administration, and the War Industries Board. Later, upon the suggestion of the council the Director General of the United States Employment Service named a representative of that organization to serve with the council.

The members met on June 8 and organized as the United Highways Council. It was decided at that meeting to take over the cooperative arrangements which were already in operation between the Office of Public Roads and the Capital Issues Committee relating to highway bond issues, and between the Office of Public Roads and the Fuel Administration regarding the distribution of road oils, asphalts, and tars.

Purpose and policy of the council.—The purpose and policy of the council were set forth in an announcement issued by the council June 20, explaining the functions of all Government agencies so far as they related to streets and highways, so as to eliminate delays, financial loss, and uncertainty incident to the handling of street and highway questions with each Government agency in turn. The policy of the council was more fully set forth in Bulletin No. 1, dated August 5, which urged the restriction of street and highway work to the most essential needs and outlined the character of the work the council would be disposed to recognize favorably. This bulletin was followed by Bulletin No. 2, dated August 27, explaining the policy of procedure as to petroleum, asphalt, and tar products for highway work; and by Bulletin No. 3, dated September 23, dealing with highway bridges. Letters were sent from time to time to the State highway departments further explaining policy.

Procedure of the council.—It was provided at the outset that application for approval of highway and street work should be submitted through the respective State highway departments to the council on a prescribed form, known as "H. C. 3," and that approval of the council should be by minute and the issuance of formal notice of approval by the secretary of the council. To expedite the handling of individual applications a subcommittee was formed to meet daily for the purpose of taking initial action on applications, which initial action was later subject to confirmation either by the council in full meeting or by the member of the council not present at the subcommittee meeting whose department was directly concerned. Two representatives of the Office of Public Roads also served as a subcommittee, passing upon applications for approval of bituminous materials for highway maintenance. Permits were issued by the Fuel Administration to carry out the findings of the council as to oils, asphalts, and tars for highway purposes, and the War Industries Board issued Circular 21, dated September 3, in which it was set forth that highway projects approved by the United States Highways Council needed no further license, permit, or priority. The Railroad Administration, by Car Service Circular No. 13, dated

May 24, just prior to the actual formation of the council, recognized the recommendations of the representatives of the Government agencies holding membership on the council in the granting of cars for the transportation of highway materials. Thus was established the coordination of the various agencies concerned. The cooperation of the United States Employment Service brought to the council effective cooperation in connection with the important element of labor.

Work performed.—From the first meeting, June 8, to the last, December 31, 1918, the full council held 27 meetings and the subcommittee 112. These meetings were in addition to the service rendered by the subcommittee of the Office of Public Roads.

Applications for approval, including those which had been submitted to the Office of Public Roads prior to the establishment of the council, reached a total of 7,307. Many of these were considered several times by reason of requests for reconsideration, or of requirements by the council for further information, so that the total number under consideration aggregated 9,712. No statement as to the exact number of approvals or disapprovals can be given, as many cases were merely deferred and not disapproved, others were conditionally approved or disapproved, others were reconsidered, and still others were affected by an amendment issued September 26 by the War Industries Board to Circular 21, permitting the completion to November 1 of projects substantially under way. Still other projects were pending at the time the council ceased its activities, and in consequence it is impossible to segregate those applications which might be considered as definitely disapproved. A quantitative table dealing with the materials, transportation, and funds involved and showing such proportion as had been definitely approved has been prepared, however, and is submitted, as follows:

TABLE I.

Item.	Unit.	Requested.	Approved.
Capital issued[1]	Dollars	[illegible]	[illegible]
Road oil	Gallons	[illegible]	44,269,826
Tar	do	56,608,832	[illegible]
Asphalt	Tons	190,207	159,475
Cement	Barrels	5,657,390	[illegible]
Brick	Thousands	109,125	52,239
Steel:			
Structural	Pounds	10,663,250	[illegible]
Reinforcing	do	[illegible]	[illegible]
Crushed stone	Tons	[illegible]	1,827,795
Gravel	do	1,204,552	[illegible]
Sand and screenings	do	2,216,481	[illegible]
Slag	do	520,152	250,428
Corrugated iron culverts	Linear feet	107,815	[illegible]
Piling timber	do	154,102	[illegible]
Pipe:			
Vitrified drain	do	2,165,419	99,699
Cast-iron drain	do	47,052	43,740
Lumber	Feet (B. M.)	5,530,196	1,651,635
Granite blocks	Blocks	1,420,500	[illegible]
Miscellaneous	Tons	[illegible]	49,513
Cars:			
Open top	Cars	[illegible]	[illegible]
Box	do	[illegible]	3,376
Flat	do	3,705	[illegible]

[1] Includes applications acted on by Bureau of Public Roads prior to formal organization of United States Highways Council, requested $28,748,084, approved $3,114,381. The Capital Issues Committee has jurisdiction and the council served merely as an aid to the committee.

The approval of the council obtained for highway purposes the equivalent of 99,000,000 gallons of road oils and tars and 159,475 tons of asphalts at a time when serious doubt existed as to whether any substantial amount of bituminous material could be made available for street and highway purposes. In other words, critics of the council might bear in mind not so much the negative action of the council as its constructive help to highways in securing a vast amount of material which might otherwise have been difficult to obtain. It is further worthy of comment that in the matter of railroad cars no action by the council restricted in the slightest degree the opportunities of shippers to obtain cars from local railroad companies. The requests, therefore, that came to the council for cars were for constructive aid rather than for approval. Through the activities of the council more than 30,000 cars were obtained for highway purposes. This number constitutes a distinct net gain to highway needs over and above the supply which the local railroads were able to furnish of their own accord.

The restriction of highway work undoubtedly served to provide for the most worthy projects such materials as were available and to bring about on the parts of the States, cities, and counties a much more thorough sifting of the various projects comprised in this form of public improvement than would otherwise have been possible. Had the war continued this conservative and selective consideration would have become more and more useful and necessary, even though it might have been desirable to change the method in which the work of the council was conducted.

Cost of activities.—On account of the facilities made available by the office of public roads the active work of the council was largely conducted and most of the quarters, personnel, and equipment furnished by that office. A summary of the cost of the handling of the applications received is shown in the following table:

TABLE II.

Number of applications, [illegible]

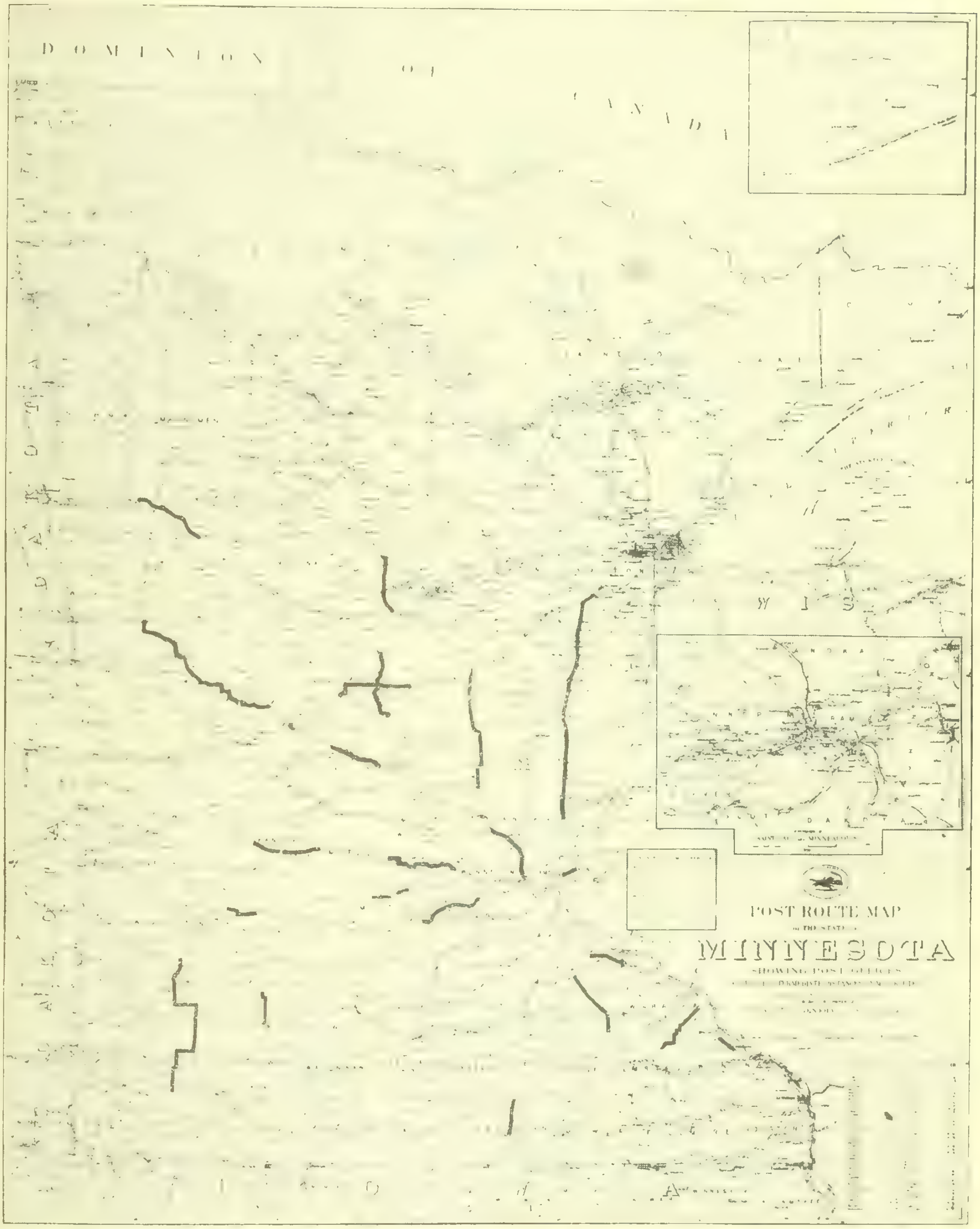
Feature.	Cost.	Cost per application.
[illegible]	$1,229.87	$0.17
Record of action	1,095.39	[illegible]
[illegible]	2,284.30	[illegible]
[illegible]	2,265.36	.31
Executive	2,363.20	.32
Administration	1,084.53	.15
	[illegible]	1.41

Records and papers, all applications, correspondence, statistical records, announcements issued, and forms used have been arranged in orderly manner and are fully segregated on the record of the Bureau of Public Roads. These papers will be kept a reasonable length of time for such disposition as may be ordered by the personnel of the council, or by the Secretary of Agriculture.

COOPERATION BY STATE HIGHWAY DEPARTMENTS.

The patriotic and thorough cooperation extended to the council by the respective State highway departments served to render the activities of the council effective throughout the entire Nation with remarkable promptness and completeness. The State highway departments lost no time in communicating with the various counties and municipalities and in making the policy of the council thoroughly understood. The State highway departments passed conscientiously upon the various applications submitted to them and for the most part disapproved at the outset those projects which had no justification under war conditions.

FEDERAL AID STATE MAPS



TYPICAL FEDERAL AID STATE MAP SHOWING GENERAL SCHEME AND TENDENCY TO MAKE THE PROJECTS IMPORTANT LINKS IN COMPLETE HIGHWAY SYSTEMS.

One of the most interesting, as well as one of the most valuable records which the Bureau of Public Roads possesses is its series of large State maps, on which Federal aid projects are entered as they are approved. The accompanying map of Minnesota shows the general scheme used, except that on the maps themselves the routes are colored yellow when the project statement is approved, which color is changed to red when the plans are approved, and this in turn to black when the project is completed.

The maps are always available for reference and are invaluable as a means of showing the relation between the projects in each State. Indeed, one of the facts which these maps already reveal, is that Federal aid is developing systematically and that what have, at times, seemed to be hopelessly isolated sections of road are in fact important links in well thought-out highway systems.

PENNSYLVANIA SEES END OF MUD AGE

By WM. C. SPROUL, Governor of Pennsylvania.

LAST fall I covered many miles of road in northern Cambria County in an automobile. The trip was a delightful one. The dirt roads were in splendid condition; but as we whirled along the highway I though of conditions when winter came, and in my mind glimpsed the sodden ribbon of mud that must come with the rain and snow—a mud ribbon that would throttle trade, prevent neighborly intercourse, and cause tremendous monetary loss. I seemed to see mired automobiles, teams of tired horses steaming from the effort to get to market loads of produce woefully small because of road conditions, and as the Cambria County people with me in the automobile pointed out the glories of the countryside I could not help but wonder how long it would be before Pennsylvania awoke to the fact that its poor roads are a brake on the wheels of progress.

A short while afterwards came the November election, and the people of Pennsylvania gave a majority of 262,000 votes to the proposition to bond the Commonwealth for $50,000,000 for road purposes. I knew then that we in Pennsylvania were nearing the end of the mud age. Since that time we have completed our plans for Pennsylvania's system of primary highways—planned to give the State a network of north-south and east-west thoroughfares which will connect every county and, meeting the highways of other commonwealths at our boundaries, place Pennsylvania in communication with a multitude of markets and sources of supply.

USE ROADS WHILE PAYING FOR THEM.

In the work of permanentizing Pennsylvania's highways we are being joined by a large number of counties. We have been promised many millions of dollars to be used in conjunction with our funds on State-aid highways, while the majority of counties in the State are also preparing to spend their own money on the construction of necessary laterals or crossroads, connecting our primary highways. The administration is particularly pleased with the willingness of county commissioners to cooperate in highway construction. And we are pleased that the people themselves look at the proposition in such a broadgauged manner and are urging their county authorities not only to spend all available money possible for better roads, but to borrow money for construction.

It seems to me that the theory that we should have the use of our improved roads while paying for them is a proper one. We buy our homes and occupy them while paying for them. We borrow money for the purpose of extending our business. We bond the State to pay for roads the use of which we have while paying the bills. A county bonds itself for road purposes, and the construction of better highways increases property values and lessens production costs.

But it is important to remember that borrowing money with which to build roads which will have disappeared or are useless before the borrowed money has been repaid is an economic fallacy. When we buy home we expect—we know—that the house with proper care will be practically as good as ever when we have finished paying for it. Under the construction method planned by the Commonwealth the life of the roads will be much longer than the life of the bonds issued to pay the bills. It is important that construction by counties be of the same durable nature. Taxpayers are never averse to spending money when they know that the return is 100 cents for every dollar expended.

BAD ROADS A LIABILITY.

During the next four years the Commonwealth of Pennsylvania will spend approximately $100,000,000 for better roads, and we are going to have $100,000,000 worth of roads. Not only that, we are going to continue to have that $100,000,000 worth of roads for years after we have paid the bills, which is, after all, the most important thing to remember.

Pennsylvania must not stop with that initial expenditure. It must continue to construct permanent highways until every hamlet and every farm is either on an improved highway or within a very short distance of one. There are 10,235 miles of road in the State's highway system—the system of roads controlled by the Commonwealth. There are approximately 90,000 miles of roads of all sorts in Pennsylvania. The State is bearing the entire cost of constructing the primary system. It asks that each county expend on secondary routes the money that it would have spent on primary routes had not the State shouldered the burden.

The State of Pennsylvania has innumerable assets, and it has one liability which we hope soon to wipe from the slate—bad roads.

HIGHWAY ENGINEERING COURSE.

The regents of the University of Nebraska have been asked to institute courses of instruction in highway engineering in conjunction with the course in civil engineering. It is argued that road building in the State is just now beginning and will continue for many years, and there will be a big demand for men trained especially for this line of work.

USE OF CALCIUM CHLORIDE AS DUST PREVENTIVE FOR GRAVEL ROADS

By W. LEROY ULRICH, Superintendent Repairs, Connecticut State Highway Commission.

CALCIUM chloride, used as a dust preventative on gravel roads passing through sparsely settled sections, has proven to be a very satisfactory treatment. The results obtained with several types of gravel roads under various climatic and traffic conditions, while differing considerably, have in each case justified its use.

This material is a deliquescent salt which may be purchased in solution, in a granular form, or as a solid. It is most economical to purchase granular chloride. In this condition it may be applied dry, which is very advantageous in sections where water must be pumped to make a solution of proper strength.

This material is put up in metal drums, holding about 350 pounds per drum, and costs at the present time between $20 and $30 per ton at the point of shipment. The price varies with the amount purchased. The drums will be painted by the shippers without extra charge if requested. If this is done, material may be stored for future use in any reasonably dry place. If it is not done, the drums, being very light-gauge material, quickly rust out, exposing the chloride to the air, from which it immediately attracts moisture and solidifies, in which form it is very expensive to handle. If properly sealed and handled, when the drum is opened it will roll out in the form of kernels about the size and appearance of popcorn. When spread upon the surface of the road it attracts and holds moisture, melting down and sinking into the surface, leaving it damp exactly as if it had been lightly watered.

In order that this application may be most successful, the surface of the road to which the material is applied must be such that it will of its own nature assist the chloride in retaining the water attracted by it. For this reason any road which has previously been treated with oil, even of the lightest consistency, should not be treated with chloride.

The surface of graded and gravel roads, as generally constructed, conform almost perfectly to the requirements of this material. Specifications for these types usually require the addition of a certain per cent of clay or earth binder whenever the native material is dry and sandy. Graded roads are usually constructed in locations which do not warrant the use of a dust layer. Chloride may be used on macadam roads, but such treatments are not generally successful unless the traffic is too light to warrant the expense of bituminous covering or where local conditions make the use of such bituminous covering objectionable, as in the case of some park drives. The most practical application for this material is upon the surface of gravel roads.

DRAG ROAD BEFORE TREATMENT.

In order to obtain the best results the surface of the road to be treated should be kept in shape by the use of a drag for about two weeks previous to the application of the material. This will insure proper cross section and a reasonably smooth surface for receiving the material. The application may be made by laborers spreading with shovels, but this is not satisfactory on long sections, as it is too slow and expensive. A uniform distribution can not be obtained by this method. Any ordinary lime sower will spread the chloride, but it is economical to purchase the most practical machine for this purpose. This is one which has a double set of agitators and an adjustable opening to regulate the amount delivered. These machines may be purchased in different widths for use with a single horse or a pair.

In making application with the use of horses the drums are distributed along the road at regular intervals, one at a point if a narrow machine is used, and two if the wider. The necessary interval is determined by the amount of material to be applied. About 1½ pounds per square yard is necessary for the first application, which should be followed by a second treatment at 1 pound per square yard. The interval between applications depends upon the quality and condition of the surface on which the material is spread and the character and volume of the traffic carried. Under moderate traffic a good surface would not require more than two applications per year; under heavy traffic three may be necessary. The best results are obtained if the material is spread on the road after a rain, when it is wet, as a better penetration is obtained at this time.

METHOD OF DISTRIBUTION.

In making an application with a two-horse machine with a spread of 10 feet, two drums are distributed every 220 feet. This machine will hold the contents of two drums and after filling is run up one side and down the other and then up the middle of the road, stopping at the point where the next two drums have been placed. This applies a little less than 1 pound per square yard on each edge of the road and nearly 2 pounds on the center 10 feet. This method has proven more satisfactory than making an even distribution over the entire surface. The same method may be followed with the one-horse machine.

In order to eliminate the necessity for the distribution of the drums, the machine may be hauled behind and fed directly from an automobile truck. Eighteen drums may be carried on a 3-ton truck, which, running continuously in one direction, will cover one width for about 6,200 feet. Three trips will complete the treatment of this length of road. This has proven a little more economical than distributing the drums and spreading with horses.

During the handling of the material, all workmen should wear rubber boots, as the chemical action of the chloride is very detrimental to leather. It is also well to provide cotton gloves, otherwise the hands will soon become sore. The hoofs and hocks of the horses, which are working on the distributor, should be cleaned and greased night and morning. After the chloride is melted on to the surface of the road, it will not cause injury to horses or to automobile tires.

SMOOTH AND DUSTLESS ROAD.

Proper application of calcium chloride results in a smooth and practically dustless surface, making a road with almost ideal riding qualities. While not considered as a binder this treatment does toughen the surface, making it less liable to ravel. One of the greatest advantages of roads treated in this manner is the ease with which the resulting surface may be maintained. All that is required is a light dragging at intervals in order to keep the surface smooth. On account of the moisture held in the surface this may be done whenever necessary without waiting for a rain.

The surface of most gravel roads softens up in the spring when the frost is leaving the ground and the calcium treatment does not overcome this condition. The results in Connecticut show that the treated roads do not mud up any more than untreated roads of the same quality and not as much as roads of this quality which have been treated with a nonasphaltic oil. The continued use of chloride has an accumulative effect. After two or three years, with two applications per year, the effect of the material is plainly noticeable in the spring, after the road has settled.

The cost of application of the material varies according to labor and local rates for teams and trucks. During the year of 1918, with labor at approximately $2.75, teams at $7.50, 3-ton trucks at $25, the cost of this treatment in Connecticut per square yard per year (two applications) has been $0.031, divided as follows: Chloride $0.026, handling and application $0.005.

WORK ON OHIO PROJECT NO. 1 RUSHED TO MOVE ARMY TRUCKS

IN August, 1917, the State highway department of Ohio submitted to the Federal Government a project (No. 1) statement for the improvement of the portion of the National Pike located between Zanesville and New Concord, in Muskingum County. The National Pike is one of the historic roads of the county, being the direct road between Cincinnati, Columbus, and Washington. In the early days it was used for communication and transportation between Washington and the West.

The national highway has been improved and modernized, although a great many of the old masonry structures remain and are in comparatively good shape. On account of its importance as a direct route for trucks between Detroit, Cleveland, Columbus, Cincinnati, and other points west, to Washington, it has been kept in very good shape, with the exception of a few stretches. One of these unimproved sections was this section presented by the State of Ohio as a Federal project under the Federal aid act.

It was proposed at the time the project was submitted to proceed with the work in the regular fashion, letting the work to contract after duly advertising for bids. Early in 1918, however, the Federal Government advocated the early completion of this contract in order to facilitate the movement of Army trucks and other war munitions east. The matter was taken up with Gov. Cox, of Ohio, and through the State highway department, with the approval of the Secretary of Agriculture, a contract was let on a cost-plus basis with a time limit, and a bonus for completion under this time limit, and a penalty for failure to complete within the time limit.

The length of the project was 13.63 miles, and the estimated cost nearly $500,000, on which the Federal Government agreed to pay $136,300 as its share of the cost. This Federal aid was the maximum amount allowed under the law at that time, namely, $10,000 per mile. The type of construction finally selected was a brick with a mastic filler on a sandstone rolled foundation. The contract was dated the 22d day of March, 1918. Work was started about the 1st of May, 1918, and practically completed about the latter part of October. It may be said that the entire 14 miles were completed in approximately six months. The cost was undoubtedly more than it would have been by the usual form of contract, but it was considered that the time gained was well worth the difference.

USE OF SAND CLAY FROM SALT FLATS IN SURFACING TEXAS ROADS

By RICHARD H. PHILLIPS, County Engineer Aransas County, Tex.

THE MATERIAL heretofore used for road surfacing in Aransas County, Tex, has generally been oyster shells in varying forms and condition. At some points heavy shell were used, followed with coating of finer shell mixed with sand. At other points the final coating was partially disintegrated oyster shell, while at others the final coating consisted of small fine shell (other than oyster shell), obtained from banks thrown up on the beach.

The best surfacing, locally obtainable, has been what is known as mud shell from reefs out in Aransas Bay. This mud shell—that is, the particular mixture suitable for surfacing, consists of shell from one-fourth inch up to full sized oyster shells. The voids in this shell are filled with mud sand. This is very fine silica sand, the grains of which are coated with silt, which acts as a binder, and when the mixture is solidified under traffic a very firm road bed results. This silt, coming from the salt water of the bay, holds the moisture and adds to the binding quality of the mixture.

In times of very low water these mud shell reefs can be reached with wagons by building up a temporary road from mainland, but this renders the supply uncertain. Resort was had to barges, the material being shoveled onto the barges at the reefs, and thence into wagons after the barges had been towed to the mainland. However, the demand has not been sufficient to provide steady employment for those equipped to deliver either by barge or wagon; hence it has been difficult to obtain deliveries when needed.

This condition led to a trial of material from salt flats adjacent to the roads, its composition being about the same as that part of the "mudshell" which filled the voids of the coarser material.

SAND CLAY IN THE SALT FLATS.

The deposits of sand clay in salt flats vary in composition, but for use in road making enough silt or earthy matter must be present to form a film or coating to the grains of fine sand, so that when drained of excess moisture and compacted under traffic it will form a uniform wearing surface. It develops that this material is primarily a mixture of Epsom salts and gypsum, with some impurities.

The writer has not had at hand the means for making minute tests or analyses of this material, but the following has been noted:

The deposits drawn from are located in what are known as salt flats, distant anywhere from 100 to 3,000 feet from low water at the bay shore.

Some seasons these flats are covered four to six months of each year with salt water, but most of them from which road material is obtained are covered for only two to three and one-half months of each year.

In the spring when these flats are becoming dry the salt crystallizing on the weeds and lowest points becomes quite noticeable.

Local rains cover the lowest points with water and tend to dilute the salt content, but the surface of these flats soon becomes dry through evaporation.

In some deposits the earthy content is a black silt, some dark brown, and other deposits are of a light yellowish brown. While designated as sand clay from salt flats, the sand, as can be gathered from the above description, largely predominates.

There is an excess of moisture in most deposits, which generally drains out while being hauled to the road, leaving the mass in a suitable condition for spreading. This material, evenly spread, readily compacts under traffic. Any depressions that appear are filled with shovels or by use of a blade machine or a three-blade drag.

When properly surfaced the top of the road is somewhat like a sheet asphalt surface in dry weather.

It becomes slippery in wet weather, and for that reason the crown should be made slight (not to exceed ½ inch to 1 foot). If the proper attention is paid to maintenance and repair a slope of ¼ inch to 1 foot will be sufficient.

WIDE SURFACING NECESSARY.

The roads on which sand clay has been used were surfaced in varying widths, 10, 12, 14 feet and a small amount of 16 feet, none of which were wide enough.

Vehicles, in passing, even on 16-foot widths generally have their outside wheels off the improved surface, especially where the crown is steep. In such cases the wheels, in getting back on to crowned surface, break through the edges. This being frequently repeated, soon renders the entire road unfit for heavy hauling and makes exceedingly rough going for auto traffic, either light or heavy.

To obviate this condition all roads in Aransas County designated as State highways and on which sand clay surfacing is to be used are laid out 24 feet wide with shoulders not less than 2 feet wide to be solidly rolled to same slope as the sand clay surfacing. This makes a clear width of 28 feet between curbs of bridges and culverts.

With this width of traveled roadway the wear of the surface is comparatively uniform and more easily maintained in good condition.

The data covering the use of sand clay in Aransas County can be somewhat summarized as follows:

(*a*) Width of original surfacing varied from 10 to 16 feet.

(*b*) Thickness of original surfacing varied from 3 to 6 inches.

(*c*) Foundation for surfacing: Some places used old traveled way (sandy loam), at other points graded with slips or fresnos and dragged without rolling, at other points the surfacing material dumped on the swamp or prairie grass after the side ditches had drained the roadbed, the grass in the latter case providing a better foundation than where the roadway was newly graded.

(*d*) The material was dumped without being evenly spread with the result that ruts and humps were numerous; some stretches were surfaced with material with scarcely any clay or salt content. Such stretches rapidly approached the condition that exists where deep loose sand is encountered.

LAYOUT OF IMPROVED ROADS.

The roadway for improved highways recently planned, especially that section of State highway No. 12 (Jefferson Davis Memorial Highway) between Aransas Pass and Rockport, has been laid out as follows:

1. Width of surfacing 24 feet, shoulders not less than 2 feet between culverts, curbs 12 feet.

2. Slope of crown ½ inch to to 1 foot.

3. The old traveled road is not disturbed and where possible the additional width of subgrade is brought up to the level of that of the old road. It is found that the moist sand clay will form a close bond to even the most solidly compacted surface; hence, when the new surface material has been used on undisturbed portions of the old road, the latter is found to provide a foundation of the very best.

4. Generally, the new surfacing is to be not less than 6 inches thick, but at some points where there is already an unbroken thickness of sand clay only enough is added to bring the top to uniform grade.

5. In some sections there are a few stations where the grade of old road has to be brought up to established grade with material from the side.

6. Surfacing material consists of selected sand clay from salt flats adjacent to the road, the haul varying from ¼ to 2 miles.

7. In some deposits there is from 1 to 6 inches clear sand on top. Generally there is sufficient clay present to admit of the use of 1 inch or more of the clear sand top, but in no case is any material allowed that will not properly compact under traffic or road roller when excess moisture is drained out.

THE COST OF SURFACING.

8. The cost of this surfacing has varied from 25 cents to 42½ cents per cubic yard for first ¼-mile haul, including loading and unloading, and from 5 cents to 7½ cents per cubic yard for each additional ¼-mile haul.

The spreading costs from 5 cents to 25 cents. The range in prices is due partly to care with which material was selected, the manner in which it was spread, and also the time when the work was done.

Shipyard construction and other building activities in vicinity of Rockport and Aransas Pass has tended to raise the price of both labor and teams, so that the maximum figures mentioned just about cover the cost at this date. Labor costs—that is, common labor—25 cents to 35 cents per hour and teams 55 cents to 75 cents per hour.

9. Material has generally been loaded into wagons by shoveling, but at a number of points the conditions are favorable to use of the Maney four-wheeled scraper.

10. The salt content in well-selected sand clay from salt flats prevents the surface from becoming unduly dry during the hottest seasons, and overnight sufficient moisture is absorbed to enable one to quickly distinguish roadway surfaced with this material from other portions surfaced with material from which the salt content is absent.

11. Annual wear is estimated at about three-sixteenths inch, which is approximately 73.33 cubic yards per mile. Add to this amount, say, 50 cubic yards per mile for filling depressions that develop under traffic and figuring the material at 75 cents per cubic yard applied, the maintenance cost for surfacing will run to about $100 per mile annually.

12. When a county is able to provide the equipment, a motor truck of about 2½ yards capacity provided with a bed having four doors operated separately by the driver and a special type of three-blade drag will prove to be an economical method of keeping the roadway surface in first-class condition. In addition to this, use a suitable drag or road machine promptly after rains to shape up the shoulders and ditches. An 8-ton roller will be a valuable addition to be used for compacting the shoulders and such portions of the roadway as may need attention from time to time.

13. The sand clay surfacing is somewhat slippery in wet weather, but it should be noted that the most unsatisfactory condition obtains where the surface has been allowed to become filled with ruts and humps, and the latter along with a slope already excessive present a slope as great as 1 to 2 inches to the foot. If proper maintenance of the surface is observed and no greater slope than one-half inch to the foot is allowed it will be found that but little sliding will occur on a roadway 24 feet wide, such a width being sufficient for autos to pass at usual speed without having to swerve out of direct line.

TREATING SLIPPERY SECTIONS.

14. Sections which under traffic develop a slippery surface in wet weather will be benefited by using about 50 cubic yards of fine shell (either

partially disintegrated oyster shell of size $\frac{1}{32}$ to 1 inch or fine shell other than oyster) spread evenly over the surface or use an equal amount of dry sand free from earthy matter.

15. It should be particularly noted that the life and easy maintenance of a roadway surfaced with sand clay from salt flats are predicated largely on one condition, and that is the treated width should never be less than what is required for vehicles to pass without one or both having to get off the treated surface.

Observation of the condition of various widths and with different treatments will show that the lack of width is the cause of rapid deterioration, but particularly true of sand clay roads. The wheels, in turning out, cut the edges and in returning grind off the edges still more and the raveling started spreads quickly to the surface farther in, with the result that any attempt to keep the narrow roadway in reasonably good condition takes more time and material than a roadway of proper width.

16. The surface treatment of shell or sand clay roads with either light road oil or heavy bitumen is not favored in this locality, and in no case has proven a success as far as the writer has been able to learn; that is, where the surface exposed to wear is composed of sand or shell bound with bitumen. Such treatment exhibits effect from abrasion as great as untreated sand clay from salt flats and it is more expensive to maintain than an equally uniform surface free from pockets that wear rapidly when once started to ravel.

17. The best bituminous-treated surface tried in this vicinity for dry shell road consists of a priming coat of about 0.3 gallon refined coal tar (about 1.15 specific gravity), followed with a coat of about 0.45 gallon refined coal tar (about 1.25 specific gravity), both coats applied hot.

The second coat to be followed with a layer of trap rock of size five-eighths inch down with two-thirds of the fines screened out, the amount of trap rock to be from 60 to 70 pounds per square yard. Occasional spots of bleeding to be blotted with clean dry sand, but in general the coating of trap rock should be sufficient to prevent the tar from being picked up by wheels in traffic.

18. The same kind of bituminous trap-rock treatment can be given the sand clay surface after a coating of fine dry shell free from earthy matter has been spread and ground into the sand clay surface by traffic. The sand clay surface without the dry shell will not allow sufficient bond of the bituminous trap-rock treatment.

GEORGIA TO USE FEDERAL AID FOR BUILDING PAVED ROADS.

SEVENTY per cent of the Federal-aid funds allotted by the Georgia State Highway Commission will be spent in the construction of paved roads, nearly all of which are to be concrete. That is the feature of action taken by the commission on March 20.

The highway commission sent notices to all the counties in the State that $1,320,000 of Federal-aid funds would be allotted to counties which were financially prepared to meet the necessary requirements and to begin work promptly. The result was that representatives were present at the meeting of the commission to present claims for allotments. One county asked for $2,000,000, another for $1,000,000, and practically all for sums in excess of the amount received.

In making the allotments the commission rejected a number of applications because counties making them had not yet begun work or had not made satisfactory progress on projects under previous allotments. Others were refused because counties proposed to raise the funds for meeting their obligations by bond issues and there was doubt as to the issue being authorized.

The allotments were distributed to 32 counties and ranged from $6,000 up to $200,000. The largest were $200,000 each to Bibb and Chatham Counties and $100,000 to Colquitt County. All allotments were made conditionally. Each county was to have its project statement prepared and financial arrangements completed within 10 days. Engineers were assigned for the various projects, with instructions to begin at once the preparation of project statements.

BIG PENNSYLVANIA PROGRAM.

The present legislature of Pennsylvania has appropriated over $14,000,000 for the highway department. Of this amount $5,000,000 are for permanent highway construction, $800,000 for repair of State highways within boroughs, $400,000 for maintenance of State-aid highways, $300,000 for the State's share of construction of State-aid highways, $500,000 for turnpike condemnations, $1,142,049 for second-class township road bonus, and $3,626,000 for the administration of the highway department. Another law was passed reorganizing the highway department, centralizing the authority so as to meet present demands.

USE OF LABOR-SAVING DEVICES IN CONCRETE ROAD CONSTRUCTION

By L. I. HEWES, General Inspector, Bureau of Public Roads.

AT A RECENT meeting of the Washington State Association of County Engineers in Spokane, I suggested that the study of labor-saving devices in the construction of concrete roads would be a fruitful subject for investigation and report. An analysis of the operations involved show that they consist of the following:

1. Collection and storage of materials.
2. Measuring and mixing of materials.
3. Depositing and manipulation of the concrete mass.
4. Curing of the concrete in place.

Assuming a standard design, to economize labor in the above operations without overburdening the cost by interest and depreciation on machinery remains the main object. A brief analysis of the customary operations show that current methods involve considerable theoretical waste. It is common, for example, to elevate material several times before it is finally in place: 1. It is raised by a derrick from cars on the side track and deposited in a storage pile. 2. It is raised from the storage pile to a storage bin. 3. It is raised in the delivery truck and shot into the mixer skip. 4. It is raised in the mixer skip and dumped into the mixer.

Any combination of these operations that would eliminate one or more motions would theoretically decrease the cost. A study of the four main operations is suggested by the following:

COLLECTION AND STORAGE OF MATERIALS.

The collection and storage of materials tends to be on an increasing scale as operations demonstrate the economy of longer jobs. Limitations on the length of a job appears to be (*a*) financial, (*b*) seasonal, (*c*) organization of construction operations. The financial limitation could certainly be overcome by more intelligent administration which could concentrate funds allotted for several years or borrowing money by bond issues to make funds available. The season limitations in the length of jobs must be overcome by the early execution of plans and contracts and by the use of larger machine units or a larger number of smaller machine units. The organization of operations tends to greater speed, but offers much opportunity for betterment.

It is reasonable to assume, therefore, that an analysis of a possible method for handling larger jobs is pertinent. For such larger-scale operations material will doubtless be delivered by freight at railroad sidings. The use of a derrick and bucket to unload cars into bins or storage piles has already come. Recently measuring bins have been added to the storage bins, and motor trucks with batch compartments have been used to transport the partially mixed sand and aggregate to the portable mixer at the point of placement. This chain of operations has eliminated the services of a number of shovelers at the cars and the mixers; but is not a further combination of the process possible?

MEASURING AND MIXING.

In the processes of collection and storage outlined above the measuring of the sand and aggregate has occurred in the measuring bin and is preserved in the compartment motor truck. A discussion of the relative cost of an increasing size of the measuring bin or an added number of measuring and storage bins, as against the cost of a second elevation from the storage piles to such bins, is open for investigation. It may be assumed, however, that the economy of the measuring bin in itself is undisputed. Is it not possible, then, to use the potential energy of the sand and aggregate in the measuring bin to combine and mix them when passing from the bin to the motor truck or conveyor to the job? The mixing of dry aggregate and sand, or of the complete list of concrete ingredients, is now based somewhat on the principle of the mixing bowl in the kitchen. Essentially, however, mixing of different ingredients requires their dispersion in order that they may recombine in a homogeneous distribution. Possibly a combination chute for sand and aggregate passing from the bin to the truck could be designed for simultaneous dispersion and recombination of these materials.

DISTRIBUTION AND HANDLING OF CONCRETE MASS.

The transportation by motor truck, or otherwise, of the sand and gravel to the mixer is really a part of the operation of depositing the concrete. While the truck-haul method is doubtless superior to piling sand and aggregate along the subgrade and the use of shovels and wheelbarrows, it is not yet perfect, for it is necessary (*a*) that the truck more or less damage the completed subgrade, (*b*) that the motor truck turn around and back up to the mixer to deposit the sand and aggregate in the skip. The damage to the subgrade is particularly severe in the turning and the loss of time correspondingly great. The actual mixing time while the batch is in the mixer is but a fraction of the interval between the arrival of the truck load of mixed sand and aggregate and the depositing of the wet concrete on the subgrade. The progress of the work is largely limited by the speed with which the material arrives.

If wooden header planks, "ribbons" or side forms for the concrete road were replaced by suitable channel irons such irons could probably be used as rails and material brought to the point of placement by a self-propelled truck running on this broad-gauge track. Already machines spanning the width of the paved way have been used in so-called monolithic brick construction at Paris, Ill., and on the Wayne County, Mich., roads for tamping and smoothing concrete. It might be possible to go a step farther in the construction operations on concrete roads and (*a*) either mix the concrete in stationary plants or by semiportable plants at a limited number of positions and dump into a swiftly traveling carriage running on the side channel rails to the point of placement; or (*b*) to introduce the dry ingredients of the concrete properly mixed into a modified carriage and to perform the necessary mixing and addition of water in the combined mixer and carriage while in transit to the point of placement from the measuring bins.

Both methods offer objections to be considered. Concrete must not be "killed" in transit and under method (*b*) it would be necessary to operate heavier rolling units on the channel rails and they would require careful foundation to preserve the grade. There is apparently no reason why such broad gauge channel rails could not successfully be constructed with the necessary switches, turnouts, and loops connecting the road to be constructed with the railroad sidings or sources of material, but ample play for wheel flanges would be required on the sharper curves of highways. The possibility of increased speed with a number of such rolling units combined with the use of approved striking, tamping, and smoothing machines deserves consideration.

CURING OF THE CONCRETE IN PLACE.

Additional speed in handling the curing process of concrete roads may be secured by mounting the canvas protection on rolling frames at any desirable height above the surface of the road. Such an arrangement is particularly desirable to protect new work from sudden rain and may be designed with an outer flange wheel. The necessary water supply for curing the concrete must be planned with great care. The system of flooding the surface in "checks" is to be preferred wherever the prevailing grades will permit its use.

PINS RECORD PROGRESS OF FEDERAL AID PROJECTS.

To control a large organization its chief must have before him at all times a visual record of the status of the work which his organization is doing. This is not so much for the purpose of directing individual undertakings as it is for the purpose of detecting and regulating general tendencies. Having this in mind a large map of the United States has been hung in one of the principal offices of the Bureau of Public Roads, and in this map a pin has been stuck for each Federal aid project. When the project statement is received a white pin is placed on the route of the project. When the plans are received this pin is taken out and a yellow pin put in. When construction starts a red pin replaces the yellow one. If work is too long delayed a blue ring is hung on the red pin. Other designations represent other stages of the project.

These pins have heads about a quarter of an inch in diameter, and on these heads numbers have been drawn in black. These numbers correspond to the numbers of the projects which the pins represent, so that if more information in regard to any project is desired, it can be readily obtained by calling for the files on this project.

Those who are dealing with these projects become very familiar with the location and the status of every project which has been unusual in any respect, or which, for any reason, has been delayed or has caused trouble, and a glance at the board each morning serves to show whether, during the preceding day, there has been any change in the status of such projects. However, the board is more useful still as a means of gaining a view of the status of the work of the bureau over the country as a whole. A little study of this board shows which States and which districts are pushing their work, in what regions the work is dragging, where the program of highway improvement is State wide, and where it seems to be sectional. These and many related matters stand out very clearly on this board, and the information gathered in a study of the board is constantly made use of in determining what, if any, special effort may be desirable to adjust the tendencies which are observed.

THE MASTER RECORD OF FEDERAL AID

EVERY large institution finds that there is a constant demand for carefully tabulated, accurate, and complete information as to the nature, the cost, and the progress of the work which it handles. This demand has led to the designing of a new master record covering the administration of Federal aid by the Bureau of Public Roads, which record is of more than ordinary interest, both because of its purpose and of the manner in which the information carried is to be made available to those who desire to use it.

The purpose of the record is to have at hand a tabulation which is at all times complete—that is, a tabulation which can be referred to with full confidence that all of the information in hand has been recorded. To that end, the data needed for this record is entered as soon as it is received at the bureau. In fact it is planned that as soon as the system becomes established, all information will be entered before the close of the day during which it is received. This will make it possible to furnish accurate and comprehensive information as to the status of Federal aid, as of any day, with full confidence that the information is beyond question.

CARRIES EXTENSIVE RECORDS.

The master record naturally carries the information which is most necessary for the administration of Federal aid by the bureau itself, but, in its design, the fact that the bureau is constantly called upon for miscellaneous information as to the rate at which Federal aid is being allotted, the kind of roads which are being built with Federal aid, the kind of bridges which are being constructed, not to mention minor miscellaneous information, has led to the inclusion of rather extensive records on types of construction, and such related data as experience has indicated may be of general interest.

The master record is kept by States. This is the natural division for many reasons, but the all important reason for this division is that a record so subdivided is of as much value to the States as it is to the Bureau of Public Roads, and its installation in its present form is largely due to a desire to place at the disposal of Congressmen, State officials, and legislators and others who may have proper use for this information, comprehensive records of the Federal Aid activities within their jurisdictions.

MAKES DATA AVAILABLE TO ALL.

The accompanying cut shows a sheet from the master record, from which the nature of the data recorded can be readily determined. At first glance there may seem to be some duplication, but it has been found by actual experience that, for instance, there frequently are differences between the type of construction and the estimated cost as proposed in the project statement and as submitted in the plans and the detail estimate. Other seeming duplications are for the purpose of revealing other changes which are likely to develop as the project is advanced and concerning which full and complete data is often of great value.

To make all of this data available to interested officials or to others who may have proper use for it, the master sheets have been made up on a semitransparent white paper, and all entries are made in India ink. This has been done so that blue-print copies of a sheet or of any part of a sheet can be readily prepared, it being the purpose to supply blue prints of these sheets to inquirers instead of making typewritten copies.

SOUTH'S LARGEST PROJECT PLANNED IN NORTH CAROLINA.

The State highway engineer of North Carolina has just reported the prospect of the immediate development of what seems likely to prove the largest road project in the South. For the present, the work to be undertaken is confined to Wake County, where a permanent type pavement is to be built from the Johnston County line to the Durham County line, a distance of approximately 27 miles. The surfacing will be 18 feet wide, of the most modern design, and is expected to cost somewhat more than $600,000. The route selected is that of the central highway, the most important highway in the State.

Durham County, Orange County, and Alamance County are also considering a change in the Federal-aid projects which have already been approved within their boundaries, their intention being to modify these projects so that hard surfaces shall be used wherever sand-clay surfaces were originally contemplated. The approved projects will also be extended to cover any gaps between the county boundaries.

Guilford County is also contemplating such changes in its program as may be necessary in order to connect Greensboro with the Alamance County line. If this is done, as it now appears likely that it will be, North Carolina will have a hard-surfaced highway extending from the Johnston County line below Raleigh to Greensboro, a distance of nearly 100 miles.

This notable improvement is made possible by a recent change in the North Carolina laws by which the county pays one-fourth of the cost of improvements of this kind, the State one-fourth, and the balance is met from Federal aid.

Projects of this nature show the far-sighted view taken by the State and county officials, and are to be commended as indicative of thorough appreciation of the value of through highways, connecting the State's principal centers of population, business, and agriculture.

APPORTIONMENT FOR F Y

		TOTAL
1917 —	82,689	
1918 —	163,378.20	246,067.30
1919 —	250,018.47	496,085.77
1920 —	336,091.81	832,177.58
1921 —		

FEDERAL AID POST ROAD PROJECTS

STATE - - - Ark.

PROJ NO	COUNTY	LOCAL NAME OF ROAD	PROJECT STATEMENTS SUBMITTED							
			TYPE OF CONSTRUCTION	REC'D D E	REC'D CH ENG	FOR'D	TOTAL EST COST	FED AID REQUESTED	LENGTH MI	COST PER MILE
A	B	C	D	E	F	G	H	I	J	K
1	Carroll.	Eureka Spg.-Seligman	Gravel & Earth.	3 31 17	4 14 17	4 14 17	11,891.55	5,945 77	3.110	3,823.65
2	Pulaski	Batesville Mt Vernon	Bituminous Concrete.	7-5 17	7 7 17	7 11 17	125,933.12	53,000.00	5.300	23,760.97
3	Sevier.	DeQueen-Gilham.	Gravel.	8 27 17	9-4 17	9-8 17	26,340 88	10,000.00	7.950	3,313.32
4	Miller.	Texarkana-Garland City	Gravel.	9 20 17	9 26 17	9 26 17	34,883.05	17,441.52	5.994	5,819.66
5	Lawrence	Walnut Rdg.-Cache Riv	Gravel	9 24 17	10-5 17	10-16 17	29,541.49	11,590.86	5.681	5,200 97
6	Lawrence	Walnut Rdg. N Co Line	Waterbound Macadam.	9 29 17	10-5 17	10 6 17	12,308.65	2,500 00	3.000	4,102 88
7	Miller	Fulton Road	Gravel.	9 29 17	10-5 17	10-6 17	12,732 47	2,558.48	2 000	6,366 23
8	Lonoke.	England - Keo	Water bound Macadam	11-19 17	11-23 17	11-26 17	8,871.72	3,169.00	1.970	5,312.02
9	Monroe	Brinkley Clarendon	Gravel - Surf Treated	11-24 17	12-10 17	12 14 17	74,943 66	37,471 83	8 080	9,275 20
10	Cross.	Wayne Memphis	Gravel	11 24 17	12 1 17	12 4 17	4,532.15	2,266.07	1 450	3,125 61
11	Woodruff	Cotton Plant-Des Arc	Bituminous Macadam	12 3 17	12 8 17	12 12 17	22,459.69	10,000 00	2 990	7,511 60
12	St Francis.	Wheatley-Bon Air	Gravel.	12 31 17	1-8-18	1-9-18	29,427.20	10,000.00	7 600	3,871 97
13	St Francis	Fishing Lake	Gravel	12 31 17	1 11 18	1-12 18	26,180 00	5,467 10	4 940	5,299 59
14	Jefferson	Sheridan Road	Gravel	2 25 18	3 11 18	3 13 18	21,400 50	10,000.00	5 170	4,139.36
15	Prairie	Des Arc - Calctchil Bay	Gravel Surf Treated	2 25 18	3 11 18	3 16 18	25,197 83	10,000 00	4 500	5,599 51
16	Lawrence	Walnut Rge Egypt	Water bound Macadam	3 22 18	4 30 18	5 6 18	22,698 22	7,500 00	4 570	4 966 78
17	Craighead	Nettleton, Lake City and Bay	Surf Treated Water bound Macadam	3 22 [illegible]	[illegible] 30 18	5 6 18	69,509 55	10,000 00	5 810	11,963 77
18	Benton	Eureka Spg Seligman	Gravel	3 22 18	4 15 18	4 20 18	14 236 47	7,118 23	6 050	2,353 13
19	Craighead	Jonesboro Nettleton	Bituminous Concrete	7-8 18	8 2 18	8 7-18	102,013 56	30,836 16	5 000	20,410 88
20	Poinsett	Harrisburg Truman	Gravel	7 8 18	8 5 18	8 12 18	61,029 10	30,000 00	8 840	6 926 37
21	St Francis	Wheatley Forrest City	Gravel	11-8 18	11 14 18	11-16-18	34,333 72	15,000 00	7 930	4,329.60
22	LaFayette	Buckner, Stamps and Lewisville	Gravel	11-8 18	11 14 18	11 18 18	48,950.95	22,205 52	15 420	3,174 51
	TOTAL									

PROJ NO	PROJECT STATEMENTS APPROVED				PLANS, SPECIFICATIONS AND ESTIMATES											
	APP'D BY SECY	TOTAL EST COST	FED AID REQUESTED	LENGTH	TYPE OF CONSTRUCTION	STRUCTURES OVER 20 FT NO	STRUCTURES OVER 20 FT COST TOTAL	STRUCTURES OVER 20 FT COST FA	REC'D D E	REC'D CH ENG	REC'OM'D FOR APPR'L	TOTAL EST. COST	FED AID REQUESTED	LENGTH	COST PER MILE
A	L	M	N	O	P	Q	R		S	T	U	V	W	X	Y
1	9-4 17	11,891.55	5,945.77	3.110	Gravel	—			9 8 17	9 13 17	10 5 17	11,891.88	5,945 77	3 110	3,823.65
2	7-16-17	125,933 12	53,000.00	5.300	Bituminous Concrete	—				7 19 17	R 11-8-17 7 26 17	112,788 77	55,492 00	5.5492	20,325.96
3	9-15 17	26,340 88	10,000.00	7.950	Gravel	—			9 8 17	9-12-17	R 5 31 18 9 24 17	19,610 73	9,805.36	7.950	2,466.76
4	10-4-17	34,883.05	17,441.52	5,994	Gravel	—			9 22 17	9 28 17	10-9-17	34,883 09	17,441.52	5 994	5,819.67
5	10-11-17	29,541.49	11,590.86	5.681	Gravel.					10 15 17	10-31 17	29,541.49	11,590.86	5.680	5,200.97
6	10 11-17	12,308.65	2,500 00	3 000	Water bound Macadam	—			9 29 17	10-12 17	10 31 17	8,596.76	2,500.00	3 000	2,865 58
7	10-11 17	12,732 47	2,558 48	2 000	Gravel				9 29 17	10-12 17	10 31 17	12,397.67	2,558 48	2 000	6,198.83
8	12 4 17	8,871.72	3,169 00	1 970	Water bound Macadam	-				5 8 18	5 11 18	8,871.72	3,169.00	1 970	4 503 41
9	5 10-18	74,943.66	37,471.83	8 080	Gravel Surf Treated	—				5 8 18	5 11 18	75,183 68	37,471.83	8.080	9,304 91
10	12 10-17	4,532 15	2,266 07	1 450	Gravel.	—				5-8 18	5 11 18	4,592.15	2 266.07	1 460	3,104.21
11	12 18 17	22,459.69	10,000 00	2 990	Bituminous Macadam	—				5 8-18	5 11 18	22 459.69	10 000.00	2 990	7,511.60
12	1-21 18	29,427 20	10,000 00	7 600	Gravel	—				5-8 18	5 11-18	22 368.50	10,000.00	7.600	2,943.22
13	3 14 18	26,180.00	5,467 10	4.940	Gravel	—				5 8-18	5 11 18	26,180 00	5,467.10	4.940	5,299.59
14	3-19 18	21,400 50	10,000.00	5.170	Gravel	-				5-8 18	5 11 18	21,400.50	10,000 00	5 150	4,155.44
15	3 25-18	25,197.83	10,000.00	4 500	Gravel					5 8 18	5 11 18	25,197 83	10,000 00	4 500	5,599.52
16	5 10 18	22,698.22	7,500 00	4 570	Water bound Macadam	—				5 8 18	5 11 18	22,698 22	7,500.00	4 570	4,966.78
17	5 10 18	69,509 55	10,000 00	5 810	Water bound Macadam	-				5 8 18	5 11 18	69,509.55	10,000 00	5 810	11,963 77
18	5 6 18	14,236 47	7,118 23	6.050	Gravel					5 8 18	5 11 18	13,537.98	6,768.99	6.050	2,237 68
19	3 7 19	102 013 56	30,836 16	5 000						8·3 18					
20	9 12 18	61,029 10	30,000 00	8 840	Gravel.	5	1771	885		8 6 18	10 [illegible] 18	59,885 65	29,942.82	8.850	6,766 74
21	11 23 18	34 333 72	15,000 00	7 930											
22	12 4 18	48.950 95	22,205 52	15 420	Gravel	—				11 25 18	1-6 19	48,950 95	22,205.52	15.420	3,174 51
TOTAL															

PROJ NO	PROJECT AGREEMENTS				REF NO
	EXEC'D SECT.	TOTAL EST. COST	FED AID ALLOTTED	LENGTH	
A	Z	AA	BB	CC	DD
1	10 10 17	11,891 88	5.945.77	3.110	
2	R 1-18-18 9 19 17	112,788.77	55,492 00	5.5492	
3	R 8-2-18 10-9 17	19,610 73	9,805 36	7 950	
4	10-17 17	34,883.09	17,441 52	5 994	
5	11 20 17	29,541.49	11,590.86	5.680	
6	11 20-17	8,596 76	2,500 00	3 000	
7	11 20-17	12 397 67	2,558.48	2 000	
8	5 29-18	8 871 72	3 169.00	1 970	
9					
10	5 29 18	4 532 15	2 266 07	1 460	
11	5 29 18	22,459 69	10 000.00	2 990	
12	5 29-18	22,368.50	10.000 00	7.600	
13	5 29 18	26,180 00	5 467 10	4 940	
14	5 29 18	21,400 50	10.000 00	5 150	
15	5 29 18	25,197 83	10 000 00	4 500	
16	5 29 18	22 698 22	7 500 00	4 570	
17					
18	6 7 18	13,537 98	6 768 99	6 050	
19					
20	11 30 18	53,885 65	29942 82	8 850	
21					
22					
TOTAL					

THIS SHOWS THE MASTER RECORD OF FEDERAL AID PROJECTS FOR A STATE, KEPT BY THE BUREAU OF PUBLIC ROADS.

FEBRUARY FEDERAL AID ALLOWANCES

FEBRUARY'S record of Federal aid was allowances in 69 projects of $2,126,913.26. Of these projects 41 were approvals and 28 final agreements. The estimated cost of the 643.344 miles of road they represent is $5,316,749.34. These roads will be of almost every kind of construction. Twenty-eight of them with an aggregate mileage of 228.046 are to be gravel. Earth roads aggregate 95.74 miles, topsoil construction 10.064 miles, earth and macadam 21.77, earth and gravel 8, sand clay 37.686, macadam and sand clay 12.896, gravel and sand-clay 28.9, earth and sand clay 28, macadam 60.92, plain macadam 21.8, and simple grading 2.184. There are to be 25.963 miles of concrete, 26.48 of concrete or macadam, 5.45 of reinforced concrete, 1.99 of brick or concrete, 3.234 of bituminous macadam, and 2 miles of bituminous.

The States receiving the largest allowances are: Illinois, $207,685.26 for 20.671 miles of concrete, bituminous macadam, and gravel roads, estimated to cost $509,267.05; New Mexico, $175,527.59 for 61.35 miles of plain macadam, gravel, and sand clay, having an estimated cost of $351,055.18; New Jersey, $169,230 for 16.923 miles of concrete construction, estimated to cost $716,907.20; Ohio, $164,297.85 for 17.29 miles of brick, concrete, or bituminous macadam, estimated to cost $452,261.96.

The largest allowance for a single project was $160,175.26 for 15.92 miles of concrete and bituminous macadam road in Dupage, Kane, Dekalb, Ogle, Lee, and Whiteside Counties, Ill., estimated to cost $395,898.41. This road is a portion of the Lincoln Highway. The single project in Utah which is listed has the greatest mileage. It is to be 52.8 miles long, in Millard County, its estimated cost is $172,381.44, and the allowance asked is $86,190.72. It will be a macadam road.

FEDERAL AID RECORD PROJECTS IN FEBRUARY, 1919.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	39	Madison	8.00	Gravel	Feb. 2		$58,685.00	$29,342.50
Arizona	5	Mohave	2.184	Grading	Feb. 12		50,930.00	21,840.00
Georgia	16	Meriwether	12.46	Earth, surfaced with topsoil		Feb. 28	44,899.03	21,000.00
	18	Dooly	10.42	Sand clay		Feb. 24	36,139.15	16,000.00
	19	Bleckley	7.65	do		do	38,312.40	19.000.00
	33	Troup	5.95	do		Feb. 28	44,416.70	22,000.00
Idaho	6	Idaho	21.77	Macadam and earth		Feb. 14	[1] 288,465.60	[1] 141,232.80
Illinois	1	Dupage, Kane, Dekalb, Ogle, Lee, Whiteside.	15.92	Concrete and bituminous macadam.		Feb. 1	395,898.41	160,175.26
	1		4.751	do		Feb. 21	113,368.62	47,510.00
Kentucky	5	Mercer	5.00	Macadam	Feb. 4		42,909.47	21,954.00
	11	Trigg	17.86	Gravel	Feb. 18		115,960.00	57,980.00
Louisiana	1	Rapides	16.90	do		Feb. 22	[2] 84,370.69	[2] 35,000.00
	24	Ouachita	4.82	do		Feb. 7	25,560.70	12,500.00
	25	do	7.00	do		do	44,697.15	15,000.00
	28	Iberia	8.59	do		do	46,255.22	22,000.00
	31	Avoyelles	4.27	do	Feb. 20		39,668.35	19,834.17
Minnesota	2	Chisago	31.50	do		Feb. 7	[3] 205,962.80	[3] 80,000.00
Mississippi	14	George	13.666	Sand clay		Feb. 24	26,791.68	10,000.00
	12	Pike	9.90	Gravel	Feb. 10		71,500.00	35,000.00
	41	Lawrence	11.00	do	Feb. 19		48,125.00	24,000.00
Montana	1	Wibaux	4.47	do	Feb. 3		21,607.00	10,803.50
	10	Cascade	18.00	do	Feb. 5		77,932.80	38,966.40
	35	Wibaux	5.10	do	Feb. 3		21,685.95	10,842.97
Nebraska	27	Dodge-Saunders	31.53	Earth	Feb. 12		50,050.00	25,025.00
	31	Dixon	19.60	do	Feb. 26		27,500.00	13,750.00
	32	Adams-Webster	28.00	Earth and sand clay	Feb. 24		30,204.00	19,602.00
	33	Knox	11.50	Earth	do		24,414.50	12,207.25
Nevada	20	Douglas	2.00	do	Feb. 26		11,734.58	5,867.29
New Hampshire	13	Grafton	1.60	Gravel		Feb. 21	15,806.45	7,903.22
	18	Hillsborough	0.90	do		Feb. 13	9,070.05	4,535.02
	19	Cheshire	.60	do		do	9,128.84	4,564.42
New Jersey	1	Monmouth	1.58	Concrete	Feb. 25		109,054.00	15,800.00
	5	Atlantic	3.873	do	do		161,403.00	38,730.00
	6	do	5,870	do	do		242,428.56	58,700.00
	8	Cape May	2.025	do	do		74,211.74	20,250.00
	9	do	3.575	do	do		129,809.90	35,750.00
New Mexico	5	Quay	21.80	Plain macadam		Feb. 1	[4] 112,575.18	[4] 44,550.30
	13	Valencia	28.90	Gravel and sand clay	Feb. 12		163,933.00	81,966.50
	14	Santa Fe	10.65	Gravel	Feb. 10		74,547.00	37,273.50
New York	16	Wayne-Ontario	7.45	Bituminous macadam or concrete.	Feb. 24		149,000.00	74,500.00
	17	Wayne	5.45	do	Feb. 20		109,000.00	54,500.00
	19	Franklin	2.83	do	Feb. 17		56,600.00	28,300.00
North Carolina	39	Union	12.896	Macadam and sand clay	Feb. 7		48,593.00	9,700.00
North Dakota	40	Bottineau	8.00	Earth and gravel	Feb. 17		10,175.00	5,087.00
Ohio	9	Knox	1.99	Brick or concrete		Feb. 11	71,000.00	16,666.87
	25	Highland	4.55	Macadam or concrete		Feb. 28	80,261.96	40,130.98
	26	Van Wert	10.75	Concrete or bituminous macadam.	Feb. 24		301,000.00	107,500.00
Oregon	11	Grant	2.13	Gravel		Feb. 28	42,898.46	21,449.23
	16	Wasco	2.00	Bituminous	Feb. 1		41,492.00	18,746.00
Pennsylvania	12	Northampton	5.45	Reinforced concrete		Feb. 21	250,388.71	54,500.00

[1] Revised agreement. Estimated cost increased from $250,368.03 and Federal aid allowance from $86,000.

[2] Revised agreement. Estimated cost increased from $70,047.60 and the allowance from $21,014.28.

[3] Revised agreement. Estimated cost increased from $110,000 and allowance from $55,000.

[4] Revised. Estimated cost increased from $89,101.68 and allowance from $56,287.59.

FEDERAL AID RECORD PRODUCTS IN FEBRUARY, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
South Dakota	11	Union	9.04	Gravel	Feb. 4		41,283.00	16,412.70
	12	Minnehaha	21.79	do	Feb. 10		100,606.00	39,433.64
Texas	73	Guadalupe	3.256	do		Feb. 7	12,316.25	5,000.00
	74	Travis	3.89	do		Feb. 25	23,771.41	11,345.23
	75	Falls	1.00	do	Feb. 15		11,957.64	5,978.82
	77	Taylor	11.61	do	Feb. 17		50,157.00	20,000.00
Utah	9	Millard	52.80	Macadam	Feb. 25		172,381.44	86,190.72
Virginia	12	Franklin	10.064	Topsoil		Feb. 17	66,814.99	33,407.49
	22	Caroline-Essex	4.71	Gravel	Feb. 21		32,879.60	16,439.80
	25	Pittsylvania	3.234	Bituminous macadam		Feb. 7	37,265.05	18,632.52
	26	Surry-Prince George	4.05	Gravel		Feb. 12	35,302.80	17,651.40
West Virginia	27	Barbour	3.12	Macadam		Feb. 10	45,650.00	12,000.00
	28	Tyler	1.50	Concrete		Feb. 15	36,300.00	15,000.00
Wisconsin	55	Door-Kewanee	8.66	Gravel	Feb. 19		51,003.21	17,001.07
	56	Kewanee	4.70	do	Feb. 17		22,577.50	7,529.16
	57	Shawano	7.70	do	do		58,512.85	19,504.28
	58	Outagamie	4.38	Concrete	Feb. 25		90,883.32	30,294.44
	62	Washington	2.91	do	do		62,372.64	20,790.88
	65	Winnebago	.25	do	do		5,292.99	1,764.33
			643.344				5,316,749.34	2,126,913.26

YEAR'S WORK IN ILLINOIS.

The highway construction planned for Illinois this year aggregates 700 miles of hard-surface road, to be built of brick, concrete, or bituminous macadam, of an average width of 15 feet, according to the program of the State highway department. The cost will be $14,000,000, one-half of which is the Federal aid available for Illinois. The other half is to be appropriated by the legislature now in session. More than the amount needed is in the State treasury, realized from automobile fees. Of the total $4,900,000 unexpended because of the war conditions must be reappropriated, $2,700,000 were paid in by automobilists in 1918 and this year $3,000,000 more will come in this year from the same source. None of this money comes from the $60,000,000 bond-issue fund.

It is planned to do the earliest work on the Dixie Highway route between Chicago and Danville, the Lincoln Highway from Chicago to Fulton on the Iowa line, the Ivy trail from Chicago to East St. Louis and the Cumberland Highway from East St. Louis to Marshall, via Vandalia.

NEVADA'S FEDERAL AID PLANS.

Nevada's Legislature of 1917 met one of the requirements of the Federal aid act by the creation of a State highway department. The first report of the directors of the department, covering the years 1917–1918, has just been issued. A considerable portion of the report is made up of the discussion of the application of Federal aid to Nevada roads, and a reading of it shows that to date most of the activities of the department have been confined to Federal aid projects. Up to the end of 1918 the department had made application to the Secretary of Agriculture for aid in 20 Federal aid projects and one forest reserve road project. Of the 20 applications, 13 had been approved and final agreements signed for 8 of them up to December 31, the date the report closes. Since that date the remaining 6 projects have been approved. These roads will have a total mileage of 225.5, with an estimated cost of $1,194,263.68. The forestry project is 16 miles long and is estimated to cost $32,000.

The law creating the highway department designated a system of State highways, having an aggregate length of 1,450 miles. Up to the end of last year the department had permanently located 242 miles of this system.

TEXAS' $75,000,000 BOND LAW.

[Houston Chronicle.]

Every member of the legislature who voted for the constitutional amendment providing for issuance of $75,000,000 of bonds for the purpose of building good roads deserves the thanks of the people of Texas.

* * * * *

No man can adequately forecast what it will mean to Texas to be threaded with a system of substantial highways.

They will increase taxable values five times $75,000,000 in five years.

They will save every year more than enough on the wear and tear of vehicles to pay the interest on the $75,000,000 at 5 per cent.

This statement is easily proved. If there are 4,000,000 people in Texas—and there are more—that means 800,000 families.

If there is only one vehicle worth $50 to a family, the aggregate is $40,000,000. If good roads save only 10 per cent of wear and tear each year, it will be $4,000,000. Five per cent on $75,000,000 is only $3,750,000.

The tax on autos will meet the interest and sinking fund, but if there was no auto tax, 20 cents on the $100, or $2 on the $1,000, is the utmost limit of tax that can be levied.

The aggregate taxable values of Texas is about $2,750,000,000. Divided between 800,000 heads of families, it averages in round numbers $3,450. The tax at full 20 cents would be about $6.89 per head of family.

Two trips saved hauling 8 bales of cotton to market 15 miles over good roads will pay the tax, to say nothing of the wear and tear of vehicles and teams, because on good roads two good mules can haul four bales at a load; whereas over ordinary dirt roads in fall and winter they can scarcely haul two, and frequently can not haul an empty wagon. * * *

TESTS OF ROAD BUILDING ROCK IN 1918

DURING 1916 Department of Agriculture Bulletin No. 370, entitled "The Results of Physical Tests of Road Building Rock," was published. This bulletin contains the results of all tests made in the laboratories of the Bureau of Public Roads up to January 1, 1916, together with brief descriptions of the tests and interpretation of the results. Tests of road building rock made since 1915 have been published about the first of each succeeding year in bulletin form, the latest bulletin, No. 670, containing results of all tests made in 1916 and 1917. As a relatively small number of rocks were tested during 1918, it has not been deemed advisable at this time to issue a revision of Bulletin No. 670 but to defer such revision until the end of 1919.

For the use of engineers interested in these tests, the following tables show results obtained in 1918. These tables may be considered as a supplement to Department of Agriculture Bulletins Nos. 370 and 670.

Results of physical tests of road building rock from the United States from Jan. 1, 1918 to Jan. 1, 1919.

Serial No.	Town or city.	County.	Name of material.	Weight per cubic foot.	Absorption per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
	ALABAMA.									
				Pounds.	*Pounds.*					
13387	Anniston	Calhoun	Limestone	170	0.22	6.8	5.9	14.7	4	23
13388	do	do	Magnesian limestone	174	.64	6.0	6.7	17.3	9	40
13389	Anniston (near)	do	Limestone	169	.269	4.8	8.3	14.7	9	33
13390	Anniston	do	Siliceous dolomite	175	.295	4.6	8.7	17.3	6	48
13504	Weavers Cave	do		172	.885	7.2	5.5	(1)	(1)	28
13506	Anniston	do	Sandstone	154	1.33	6.1	6.5	19.1	10	(1)
13507	do	do	Limestone	169	.157	4.7	8.5	15.3	8	34
13508	do	do	do	172	.68	11.6	3.4	(1)	(1)	27
13509	do	do	do	140	.123	5.4	7.4	16.0	6	21
13510	do	do	Dolomite	175	.376	5.0	8.0	16.0	8	28
13505	Birmingham	Jefferson	Chert	147	5.82	(1)	(1)	(1)	(1)	48
12757	[2]	Morgan	Limestone	168	.106	3.8	10.5	14.5	9	35
12758	[2]	do	do	166	.378	5.4	7.4	11.9	7	47
12812	[2]	do	do	167	.19	6.0	6.7	13.3	6	31
	ARKANSAS.									
12993	Little Rock	Pulaski	Quartzite	165	0.38	3.3	12.1	19.3	26	9
12994	do	do	do	165	.27	3.3	12.1	19.0	23	(1)
13295	White Cliffs	Sevier	Argillaceous limestone	(1)	(1)	13.9	2.9	0.0	(1)	43
	DELAWARE.									
12839	Faulkland	New Castle	Hypersthene gneiss	184	0.044	4.0	10.0	18.0	14	(1)
13033	Yorklyn	do	Hornblende gneiss	173	.225	3.2	12.5	18.3	10	(1)
13838	Faulkland	do	do	181	.31	3.7	10.8	18.7	12	(1)
	FLORIDA.									
13788	Floral City	Citrus	Weathered chert	(1)	(1)	17.9	2.2	(1)	(1)	9
13568	Montbrook	Levy	Chert	148	4.22	15.6	2.6	17.3	16	39
13301	Chipley	Washington	Limestone	156	2.37	12.3	3.3	14.4	5	28
	GEORGIA.									
12933	Near Cartersville	Bartow	Dolomite	174	1.02	3.9	10.2	16.0	8	12
12957	do	do	do	173	.345	3.9	10.3	18.0	6	11
13845	Macon	Bibb	Granite gneiss	168	1.2	5.9	6.8	18.0	9	(1)
13502	Lithonia	Dekalb	Granite	166	.49	6.1	6.6	(1)	8	(1)
13533	do	do	do	164	.54	5.4	7.4	(1)	9	(1)
	ILLINOIS.									
13297	Lehigh	Kankakee	Dolomite	162	2.60	4.6	8.7	12.7	7	17
	INDIANA.									
12889	Bedford	Lawrence	Limestone	143	7.745	(1)	(1)	0.0	4	(1)
	KENTUCKY.									
12754	Grayson	Carter	Limestone	167	0.18	5.1	7.8	15.0	11	43

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[1] Test not made.

[2] Exact locality not known.

Results of physical tests of road building rock from the United States from Jan. 1, 1918, to Jan. 1, 1919—Continued.

Serial No.	Town or city.	County	Name of material	Weight per cubic foot.	Absorption per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
			MAINE.							
				Pounds.	*Pounds.*					
12755	Portland	Cumberland	Sericite schist	170	0.18	4.1	9.8	17.3	14	(1)
12756	do	do	Granite	166	.24	3.8	10.5	18.0	10	(1)
13854	Vinal Haven	Knox	do	(1)	(1)	3.3	12.1	18.7	13	(1)
			MARYLAND.							
12802	Port Deposit	Cecil	Hornblende biotite schist	169	0.012	2.8	14.3	17.3	17	(1)
12930	Near Frederick	Frederick	Argillaceous limestone	172	.14	2.6	15.4	(1)	(1)	53
13669	Kingsville (near)	Harford	Amphibolite	191	.41	4.0	10.0	17.3	10	(1)
12765	Ellicott City	Howard	Altered diabase	186	.154	(1)	(1)	(1)	(1)	40
12766	Dickerson	Montgomery	Diabase	181	.118	2.6	15.4	(1)	(1)	25
12607	Near Bethesda	do	Mica gneiss	168	.33	3.4	11.8	18.7	9	(1)
13728	[2]	Prince Georges	Diabase	(1)	(1)	1.6	25.0	(1)	(1)	(1)
			MASSACHUSETTS.							
13566	Peabody	Essex	Altered diorite	181	0.20	2.9	13.9	18.0	16	28
12852	West Townsend	Middlesex	Biotite granite	163	.26	6.9	5.8	17.3	6	(1)
13148	do	do	Granite	(1)	(1)	(1)	(1)	18.0	10	(1)
13560	Malden	do	Altered andesite	169	.11	2.0	20.0	18.7	19	20
13563	do	do	Altered rhyolite	165	.11	3.0	13.3	18.7	17	19
13562	Quincy	Norfolk	(*a*) Granite porphyry	166	.41	2.7	14.8	18.0	11	18
			(*b*) Altered slate	175	.16			14.0	17	
			(*c*) Granite	164	.40			18.7	11	
			(*d*) Granite	163	.35			18.0	9	
13559	Jamaica Plains	Suffolk	Rhyolite breccia	166	.71	4.4	9.1	18.7	8	15
13561	do	do	Conglomerate	160	.63	5.0	8.0	18.0	7	16
13564	West Roxbury	do	Altered granite	168	.18	3.4	11.8	18.7	10	(1)
13565	Boston	do	Diorite	182	.25	2.8	14.3	18.0	13	35
13567	Roxbury	do	Altered rhyolite	172	.39	4.4	9.1	17.3	11	19
			MINNESOTA.							
13725	[2]	[2]	Sandstone	187	0.24	3.8	10.6	18.7	18	13
			MISSISSIPPI.							
12692	Pontotoc	Pontotoc	Limestone	160	0.92	7.0	5.7	17.0	9	68
			NEW YORK.							
13558	Stoneco	Dutchess	Siliceous dolomite	174	0.25	2.6	15.4	16.3	29	43
12729	Buffalo	Erie	Limestone	169	.18	4.2	9.8	14.0	8	50
12727	North Le Roy	Genesee	do	168	.3	3.9	10.3	15.3	13	44
13557	Cedarcliff	Orange	do	176	.17	3.1	12.9	14.0	19	28
12714	Oregon	Putnam	Granite gneiss	166	.267	5.2	7.7	18.7	9	(1)
			NORTH CAROLINA.							
13027	New Bern	Craven	Shell limestone	(1)	(1)	49.0	0.81	(1)	(1)	23
12770	Canton	Haywood	Granite gneiss	157	1.156	20.3	2.0	17.3	6	53
13050	Dover	Jones	Fossiliferous limestone	150	3.85	10.6	3.8	(1)	(1)	25
12883	Pollocksville	do	Shell limestone	(1)	(1)	16.9	2.4	(1)	(1)	35
12888	Castle Hayne	New Hanover	Limestone	152	4.88	9.8	4.1	12.7	5	33
13527	Mount Airy	Surry	Gneiss	162	.61	5.4	7.4	(1)	11	(1)
			OHIO.							
12890	Berea	Cuyahoga	Sandstone	124	7.414	(1)	(1)	0.7	5	(1)
12891	Euclid	do	do	139	6.55	(1)	(1)	2.7	9	(1)
13073	Sandusky	Erie	Limestone	169	1.07	4.8	8.3	15.9	10	30
13074	do	do	do	166	1.56	4.7	8.5	12.4	8	69
13095	Bellevue	Huron	do	157	5.85	6.3	6.3	10.3	5	49
13093	Toledo	Lucas	Dolomite	172	.49	6.1	6.6	12.7	6	34
13179	Waterville	do	Slate	171	.40	8.6	4.6	16.0	14	39
13397	do	do	Limestone	165	.231	4.0	10.0	16.0	19	37
			PENNSYLVANIA.							
13129	Tyrone	Blair	Sandstone	160	0.134	3.3	12.1	18.7	12	6
12908	[2]	Cambria	do	152	1.48	7.4	5.4	15.3	9	(1)
13174	[2]	do	do	153	.273	6.7	6.0	18.3	8	(1)
13178	[2]	do	do	152	.274	8.2	4.9	16.7	7	(1)
12767	Berwick	Columbia	do	164	.354	4.8	8.3	18.7	14	(1)
12929		Lycoming	Limestone	169	.18	7.5	5.3	15.3	5	46
12688	Bethlehem	Northampton	do	174	.043	4.9	8.1	15.0	10	41
12690	do	do	do	171	.14	5.2	7.7	14.7	7	46
12691	do	do	do	167	.28	6.2	6.5	11.8	8	48

[1] Test not made.

[2] Exact locality not known.

Results of physical tests of road building rock from the United States from Jan. 1, 1918, to Jan. 1, 1919—Continued.

Serial No.	Town or city.	County.	Name of material.	Weight per cubic foot.	Absorption per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.	Cementing value.
			SOUTH CAROLINA.							
				Pounds.	*Pounds.*					
12863	Rock Hill	York	Altered gabbro	188	0.10	3.2	12.5	18.0	17	19
			SOUTH DAKOTA.							
13729	[2]	Minnehaha	Quartzite	(1)	(1)	(1)	(1)	19.7	17	(1)
13730	[2]	do	do	(1)	(1)	(1)	(1)	19.7	30	(1)
			TENNESSEE.							
12703	Chattanooga	Hamilton	Limestone	168	0.106	3.9	10.3	16.0	10	50
12740	do	do	do	168	.199	4.2	9.8	16.0	9	53
13064	do	do	do	169	.08	4.5	8.8	15.7	8	25
			TEXAS.							
13106	Austin	Travis	Nephelite basalt	195	0.059	2.8	14.3	18.7	29	94
			VIRGINIA.							
12853	Charlottesville	Albemarle	Mica schist	166	0.13	4.1	9.8	18.0	6	(1)
13298		do	Biotite gneiss	176	.77	6.2	6.5	16.7	7	(1)
13299	Ivy	do	Amphibolite	194	.28	3.0	13.3	17.4	14	11
13712	do	do	Biotite gneiss	176	.86	4.6	8.7	18.0	8	(1)
12915	[2]	Augusta	Siliceous limestone	174	.314	3.5	11.4	16.3	15	38
12916	[2]	do	Feldspathic sandstone	163	1.25	3.5	11.4	16.0	11	44
12917	[2]	do	do	178	.45	3.1	13.0	16.0	24	58
12918	[2]	do	Sandstone	168	.34	3.1	12.9	18.0	6	(1)
13499	Staunton	do	Limestone	175	.087	3.06	13.06	16.0	19	15
13724	Buchanan, near	Botetourt	Argillaceous limestone	173	.27	3.3	12.2	17.3	23	37
12834		Campbell	Hornblende schist	184	.27	13.5	3.0	16.3	5	(1)
12954	Lynchburg	do	Biotite schist	166	1.60	6.8	5.9	16.0	6	(1)
12984	[2]	Chesterfield	Biotite granite	163	.873	3.9	10.3	18.7	12	(1)
13193		Clarke	Limestone	166	.051	6.4	6.3	15.0	7	24
13195	The Plains	Fauquier	Epidosite	188	.50	2.4	16.6	18.3	22	13
13196	do	do	do	186	.69	7.9	5.6	16.0	17	11
13197	do	do	do	202	.54	1.8	22.2	18.3	19	8
13765	Shores	Fluvanna	Schist	181	.44	2.4	16.7	18.3	10	20
13194	Near Winchester	Frederick	Limestone	169	.018	7.5	5.3	15.3	7	27
12878	Stickleyville	Lee	Argillaceous limestone	167	.167	9.1	4.4	14.3	8	47
12879	do	do	Limestone	165	.17	5.4	7.4	13.3	6	27
12880	do	do	Ferruginous sandstone	167	.31	5.3	7.5	8.0	8	38
13176	do	do	Limestone	169	.013	6.2	6.4	16.0	8	35
13641	[2]	do	do	168	.21	5.4	7.4	15.3	11	41
12835	[2]	Nelson	Biotite gneiss	171	.204	6.5	6.2	18.0	11	(1)
13071	[2]	Pittsylvania	Quartz	165	.196	13.8	2.9	(1)	(1)	(1)
13529	[2]	do	Biotite gneiss	172	.49	4.2	9.5	18.7	10	(1)
13041	Glasgow	Rockbridge	Limestone	170	.188	4.7	8.5	16.3	9	16
13042	do	do	do	168	.203	6.4	6.3	12.7	17	15
13043	do	do	Quartzite	165	.20	3.0	13.3	(1)	(1)	(1)
12788	Hansonville	Russell	Argillaceous dolomite	169	.742	3.6	11.1	16.7	14	28
12789	[2]	do	Dolomite	175	.0789	3.3	12.1	16.7	21	56
12840	[2]	do	Limestone	171	.078	5.8	6.9	15.3	8	45
			WEST VIRGINIA.							
12728	Sattes	Kanawha	Feldspathic sandstone	155	4.67	4.6	8.7	3.0	6	(1)
13706		do	do	157	3.88	12.2	3.3	12.0	7	(1)
13396	Rivesville	Marion	Limestone	163	.502	4.3	9.3	16.0	9	24
12787	Nitro	Putnam	Feldspathic sandstone	152	2.158	11.6	3.4	....	6	66
13571	Spencer	Roane	Micaceous sandstone	156	4.22	8.9	4.5	2.0	8	(1)
13806	do	do	Calcareous sandstone	156	1.78	4.4	9.1	10.7	6	[3] 33
13296	Fetterman	Taylor	Feldspathic sandstone	154	3.91	9.2	4.3	11.7	5	(1)
			WISCONSIN.							
12615		Milwaukee	Dolomite	166	2.84	4.0	10.0	13.3	7	40
12616	[2]	do	Argillaceous dolomite	161	2.42	6.4	6.3	12.0	7	29
12617		do	do	164	3.21	4.5	8.9	14.3	10	22
12618	[2]	do	Dolomite	175	.14	6.5	6.1	16.0	6	46
12619	[2]	do	Argillaceous dolomite	167	2.66	3.7	10.8	14.3	10	46
13537	Milwaukee	do	Limestone	166	2.15	6.0	6.7	15.3	9	112

[1] Tests not made.

[2] Exact locality not known.

[3] Not reported.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45 Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913). 15c.

DEPARTMENT BULLETINS.

Dept. Bul. *53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912-13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913
136. Highway Bonds
220. Descriptive Catalogue of Road Models of Office of Public Roads.
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U.S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 13 WASHINGTON, D. C. MAY, 1919

APPROACHING DINGMANS FERRY (N. J.), ON ROAD THAT CONVICTS BUILT

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1919

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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WASHINGTON
GOVERNMENT PRINTING OFFICE
1919

COLORADO'S FIRST FEDERAL AID ROAD.

By Clyde E. Learned, Highway Engineer, Bureau of Public Roads.

BPR 16755

OLD ROAD LOOKING TOWARD DENVER, SHOWING HAND RAIL ON OLD WOODEN BRIDGE.

COLORADO'S first completed Federal aid project is 3.95 miles of concrete construction beginning at the southerly limit of the city of Denver and extending into the center of the town ot Littleton. It is the first link in the Colorado Springs Highway, being also a part of the "Great North and South Highway," and located on the Colorado State primary road No. 3. It runs within a few hundred feet of and parallel to the tracks of the Sante Fe and Denver & Rio Grande railroads, except for that portion in the town of Littleton.

Traffic over the old road was very heavy, a traffic census showing 1,200 vehicles passing every 24 hours. This was made up of tourist travel to Colorado Springs and other southern points, and a large volume of motor trucks. Upon the completion of the road the indications were that this traffic would be doubled within a short time.

The cost of the road totaled $80,703.10, and the Federal aid allotted was $37,198.49, or 46.1 per cent of the combined cost of construction and engineering.

LAID 570 FEET IN ONE DAY.

Gravel for the concrete pavement was hauled, piled, and screened along the side of the road in the winter and spring of 1918. Concrete pavement work was started on July 19 and completed November 5, 1918, 52 working days being actually consumed in the pavement work. The maximum day's run was 570 lineal feet. Final trimming of the shoulders and ditches was completed on December 21, 1918.

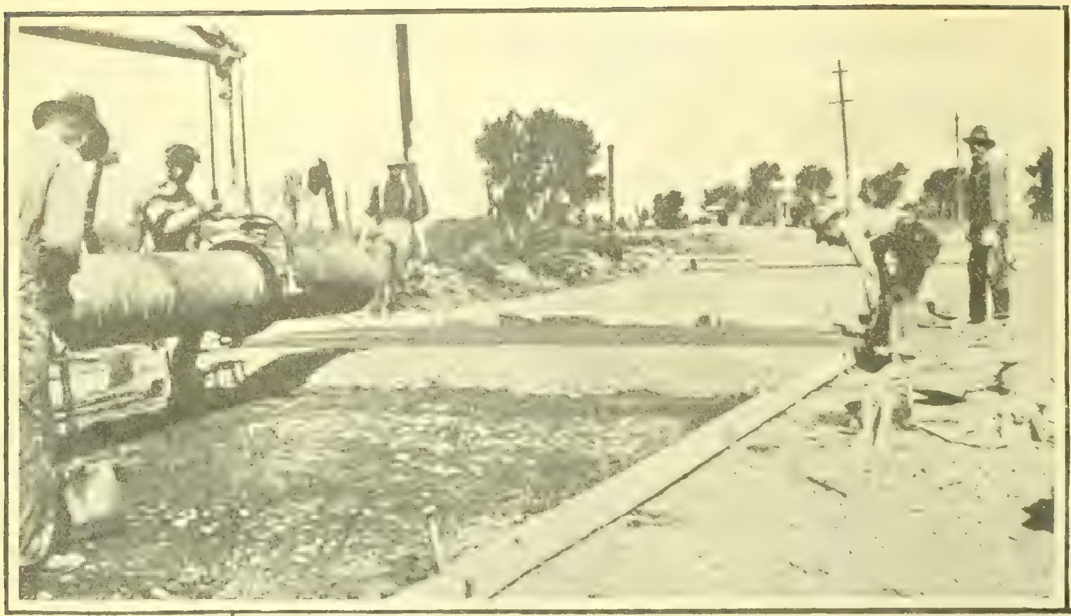
The concrete pavement is 16 feet wide with 4 feet of gravel or sand surfaced shoulders on each side.

The drainage structures included two reinforced concrete bridges, the first over Big Dry Creek, having a 28-foot span on a wooden pile foundation; the second over the Littleton electric car line tracks with a 22-foot skew span on a rock foundation. Considerable trouble was experienced in putting the concrete foundation of the bridge over the Big Dry Creek because of the gravelly nature of the foundation, which made it practically impossible to pump the cofferdams dry.

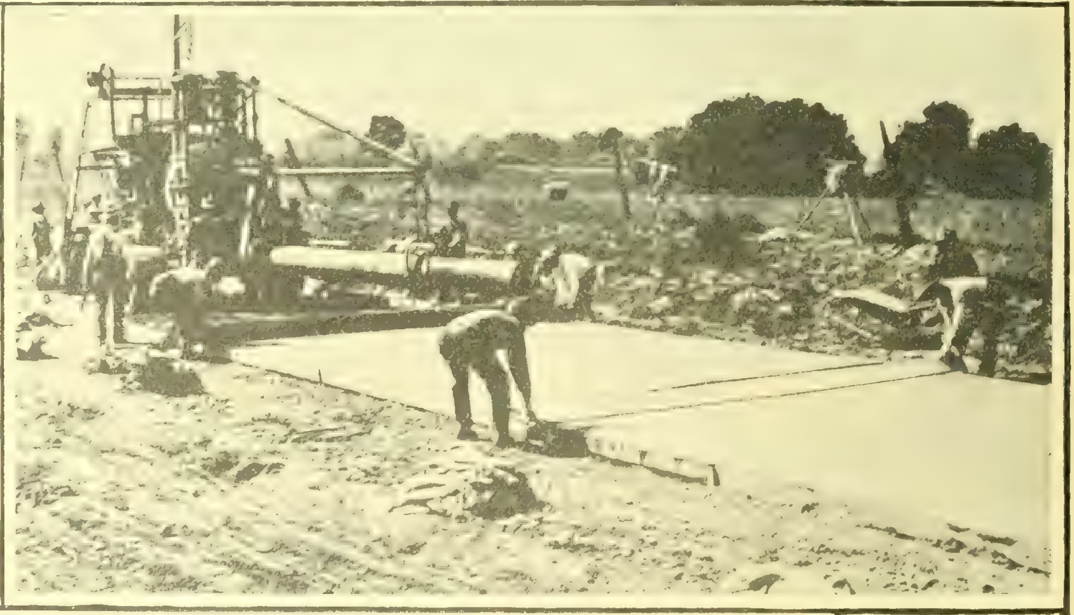
The remainder of the drainage structures consisted of 12, 15, 18, and 24 inch corrugated pipe culverts with concrete head walls. In a number of cases it was necessary to take care of the old irrigation ditches that cross the road, and in no case was it possible to use one of them for drainage purposes.

SHOULDERS VERY FLAT.

The pavement itself has a thickness of 6½ inches at the center and 5½ inches at the sides, the subgrade being flat. The finished surface conforms to the

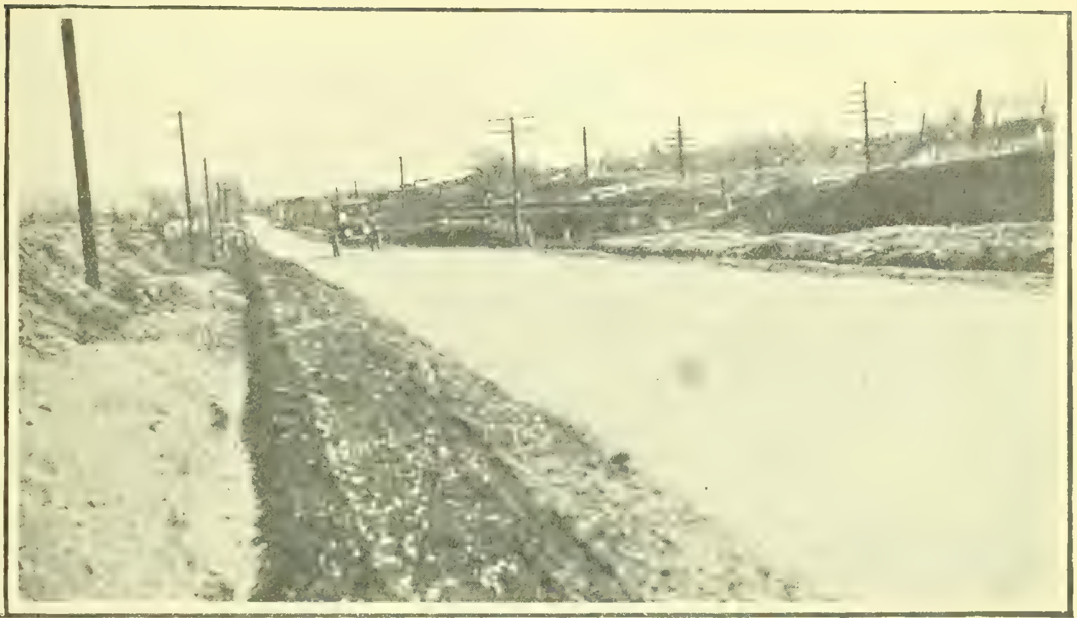


MEN STRIKING OFF—SHOWING EVEN DISTRIBUTION OF CONCRETE AND CONSISTENCY OF MIX.

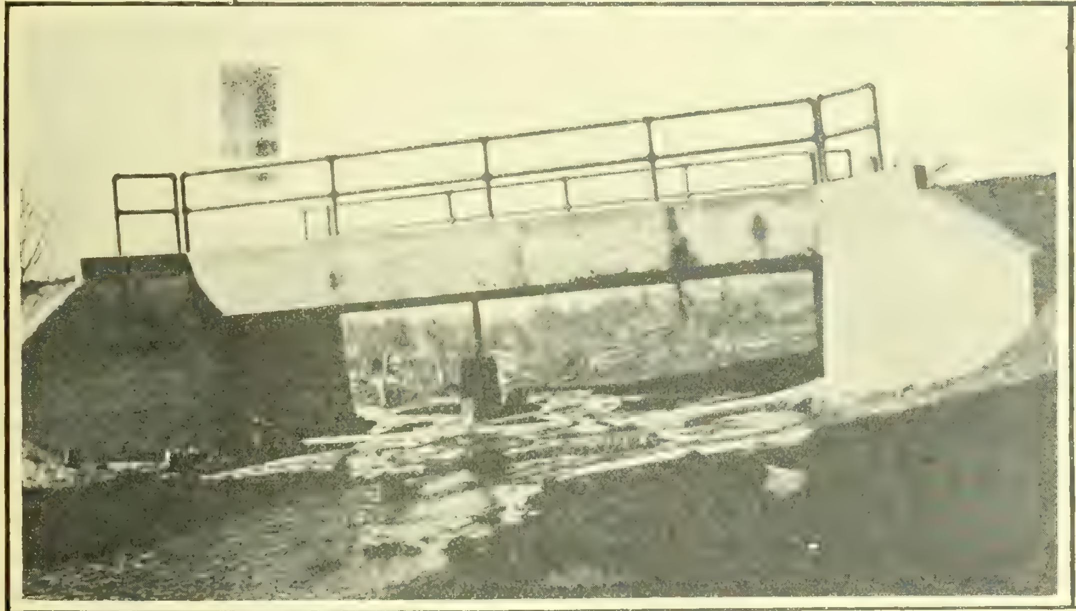


REVOLVING DISTRIBUTOR TYPE OF PAVER, SHOWING OPERATION OF STRIKING OFF AND BELTING—NOTE SURFACE AFTER BOTH OPERATIONS.

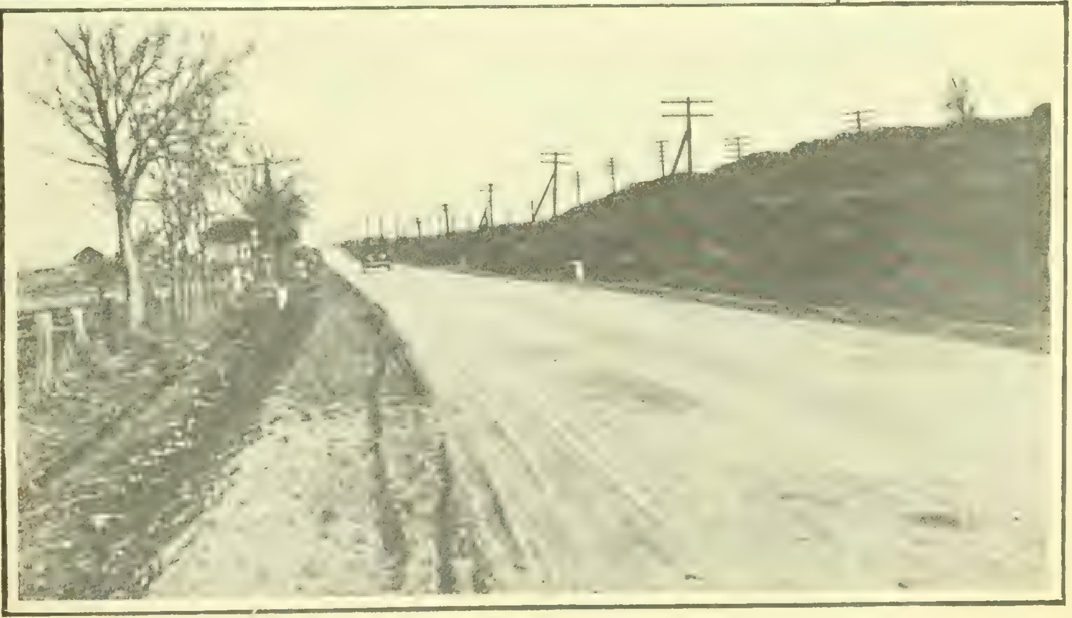
MAXIMUM DAY'S RUN 570 LINEAL FEET—MEN ARE SHOWN BELTING THE LAST BLOCK LAID.



SECTION OF FINISHED ROAD, LOOKING TOWARD DENVER NOTE THE SHALLOW V-SHAPED DITCH.



REINFORCED CONCRETE BRIDGE OVER BIG DRY CREEK, HAVING A SPAN OF 28 FEET.



ANOTHER SECTION OF FINISHED ROAD, LOOKING TOWARD DENVER SHOWING THE SAND SURFACED SHOULDERS.

arc of a circle and has a crown of 1 inch. The shoulders are surfaced with 2 inches of sand or gravel and are 4 feet in width, making a total road width out to out of shoulders 24 feet. The slope of the shoulders which are very flat is one-half inch for the 4-foot width.

The concrete was mixed in the proportion of 1 bag of cement to 2 cubic feet of sand and 3 cubic feet of screened gravel, and results from the total pavement laid showed that 1.7 barrels of cement were used per cubic yard of concrete, which was mixed to such a consistency that when struck off with the strike board the exposed face stood up almost vertical, no flow occurring and there being no separation of materials.

As the result of a number of experiments it was determined to use water per batch as follows:

17.7 gallons per batch or 33.8 gallons per cubic yard of concrete, producing a rather stiff mix which, when screeded and screed tamped, gave a very satisfactory surface upon which no excess water appeared.

Or 19.1 gallons per batch or 36.5 gallons per cubic yard of concrete, producing a mix which flowed slightly and when screeded and screed tamped gave a very satisfactory surface upon which a slight amount of water appeared.

The concrete mixer used was a paver with a rotary distributor and the results obtained were very satisfactory. The batch consisted of three and a half bags of cement, two wheelbarrows of sand and three wheelbarrows of gravel of 3½ cubic feet capacity. It required just 100 seconds to mix one batch. Eighteen batches were required for a 30-foot block, and as this block was laid in 30 minutes the normal running time was 1 linear foot of pavement per minute, and this rate of progress was maintained hour after hour when materials were on hand.

MATERIALS PROPERLY MIXED.

The materials actually were in the mixer drum 45 seconds, but as the revolving distributor was provided with blades and the total time required for the materials to pass through the distributor was 40 seconds, it was considered that the materials received at least as much, if not more, mixing than they would have received in the bucket or chute type mixer. Furthermore, the character of the resulting concrete showed that the materials were properly mixed.

The swinging revolving distributor on the mixer enabled the boy on it to spread the concrete over the whole surface to the required depth. The mixer was moved ahead each batch and it required very little hand spreading to place the concrete. This aided the two strike board men so that it was possible for them to keep up with the mixer at all times. The concrete was spread by the distributor so that there was a slight excess, or wave, in front of the strike board at all times.

TAMPING WITH STRIKE BOARD.

The strike board or screed as used on this work was built of a 2 by 10 inch plank, 2 feet longer than the width of the pavement, having a crown conforming to the typical section. The board was shod on the finishing edge with an ⅛ by 2 inch band iron and was provided with a pair of handles on each end. The first time over the board was advanced with a combined longitudinal and crosswise motion, this passage leaving the surface a series of small transverse waves with a slight excess of concrete, following this the board was used as a tamper to compact the surface in the following manner:

One of the strike board men held his end of the board on the side form, while the other tamped the concrete by a succession of short quick strokes, at the same time advancing his end about 2 inches each stroke, the total advance being 3 or 4 feet. This was then repeated by the other strike board man moving his end ahead, while the first man pivoted his end on the side form. Thus the total surface was tamped, each man's work resulting in a series of fan-shaped surfaces. This tamping filled all pockets and pushed down all protruding stones.

The strike board was passed over the surface again as at first, care being used to see that it rested on the side forms at all times. It was necessary sometimes to use the strike board four or five times over the surface so as to get the desired result, but ordinarily three passages were sufficient.

USED ROLLER ON ONLY PART OF ROAD.

After using an 80-pound roller, 10 inches in diameter and 6 feet long, on the first portion of the pavement its use was discontinued because with the type of mixer used a fairly stiff mix with no excess of water was produced, and also when the roller was used too soon it removed a portion of the 1-inch crown, which could not be afforded. Later the use of the roller was resumed upon two stations in order to determine if there was any difference in the wearing and riding quality of the rolled and unrolled sections. It was found that the roller did not roll out the crown when used at the proper time, which on this work ranged from one-half to one hour after depositing the concrete.

About one-half hour after the concrete was deposited, or after it had been rolled, the surface of the pavement was belted. For this work an 8-inch, six-ply rubber belt, 18 inches longer than the width of the pavement was used, the belt having wooden handles bolted on each end. It was first passed over each block with a long sweeping stroke about 18 inches in length, advancing at each stroke from 4 to 6 inches. On the return trip a shorter quick stroke about 8 inches in length was used, the advance being 6 to 8 inches each stroke. The third and final passage was performed by holding the belt down close to the side forms and advancing the belt by sliding it over the surface, there being no side movement. After the belting was completed the pavement presented a very smooth and uniform surface. The finisher followed with a wooden hand float, with which he floated and smoothed along the side forms for a width of about 2 feet.

EFFECT OF HOT WEATHER.

As soon as the concrete had set up a little the finisher went along the sides of the pavement and across on both sides with a sidewalk edging tool, the idea being to eliminate all sharp edges which traffic would tend to destroy.

During the hottest weather the concrete placed in the morning was sprinkled as soon as it was set up so it would not pit. This usually was about noon. Even then a number of sun or wind checks appeared, which in a number of cases lengthened out to such an extent that they produced noticeable cracks. On the night following the laying of the pavement the watchman kept it wet down, and the following morning the surface was covered with about 2 inches of material from the shoulders. This earth was continuously wetted down throughout the day and every night over the last 10 days' run until the weather became so cool that it was not necessary.

In screeding or striking off near the joints the pavement was struck off by continuing the movement of the strike board right up to the joint, all excess concrete being removed by shovels. The surface near the joint was then screed tamped and rescreeded toward the joint, making sure all excess concrete was removed. The screed was then placed at the joint and worked back zigzag over the block for a distance of 4 or 5 feet. This resulted in spreading over a large surface any excess material which may have been left adjacent to the joint. A large wooden split float was used at the joints in assuring that the concrete was at the same elevation on both sides.

SPRINKLING ALONE NOT SUFFICIENT.

It developed that the pavement work done from the latter part of September to the completion of the work was free from sun checks, whereas the work performed during the hot months of July and August had a number of such checks. In such a dry climate and with a warm wind it is practically impossible to eliminate checks by sprinkling alone, and in such cases canvas covers should be provided for covering a portion of the day's work.

A sidewalk edging tool was used on both sides of the asphalt-filled joint, and the joints were cut off about one-quarter inch above the pavement, which is the height specified in the specifications. It would have afforded more protection to the joint if the filler had been cut off one-half inch above the pavement and provision made for ironing the fillers before traffic was allowed to pass over them.

The contractor was allowed by the specifications to surface the shoulders with gravel or sand, and as he had a large surplus of sand from the gravel screening on the work, he used this. It would undoubtedly have been more satisfactory if he had been limited to gravel alone on this work.

The typical cross section provides for a slope of only one-half inch for the 4-foot width of shoulder, which is not sufficient to give the road proper surface drainage. It also provides ditches only 1 foot deep, which is not adequate for the foundation of concrete pavement.

COLORADO ROAD LEGISLATION.

The proposition agitated in Colorado for the issuance of $20,000,000 in State road bonds failed to pass in the legislative session for this year. A bond issue of $5,000,000 was, however, authorized, one-half of which is to be reserved to meet Federal aid and the other half to be distributed among the counties according to road mileage. The proposition must be voted on by the people at the general election in 1920, so that the money will not be available before 1921, if the vote is favorable.

Other legislation affecting the roads included laws levying an additional half mill tax for road purposes, an automobile license law, a gasoline tax and segregation of a portion of the inheritance tax for roads. The newly created sources of revenue will probably make available this year, $500,000.

RIGHTS-OF-WAY FOR COUNTY ROADS.

Many counties in Colorado have no record or apparent title to their roads, even some main roads, according to Chief Engineer J. E. Maloney, of the State Highway Department. He is urging the county authorities to secure at once ample rights-of-way for all roads which it is proposed to surface. The typical sections for surfaced roads, adopted by the Colorado Highway Department, call for an 18-foot or 20-foot roadway. Mr. Maloney believes that for four-fifths of the hard surfacing gravel or macadam will prove adequate for some time.

MOUNTAIN HIGHWAY RECONNAISSANCE.

By T. A. BEDFORD, Division Engineer, California State Highway Department.

THE SELECTION of highway routes in a mountainous region requires the exercise of certain well-developed faculties almost as rare as what is sometimes called "horse sense." The reconnaissance engineer must have a keen sense of proportion, course, distance, and locality; something almost akin to animal instinct. If he does not possess this, he would better specialize on something else.

Any competent engineer may, by mechanical means, take accurate topography over all possible routes between two points and by trial lines, shifting and calculating, find, in the course of time, the most economical location for a highway and yet, in the end, get it in the wrong place and have no money left with which to build.

The writer served as topographer on railroad location under just such an engineer. He was a splendid technician and a whirlwind in mathematics, but he could not find his way back to dinner without first finding the line of stakes and then followi [illegible] back to camp. On this work topography was sketched in for miles around to improve the looks of the map and then control points and influence points were found on the map. He could not see them on the ground.

DETERMINING POINTS TO BE CONNECTED.

As for methods, the first things to be determined are the points which are to be connected up by the road; next, a thorough knowledge of the topography of the intervening country should be obtained by walking out the ridges and climbing the highest peaks to get a general idea of the topography and then following out the canyons or main water courses to get a more accurate knowledge of the topography, as the road will most likely follow the watercourses. A simian ability to climb trees is a useful accomplishment for the engineer at this stage of the reconnaissance.

Thus with a mental picture of thousands of square miles of topography standing out before the mind, like a huge relief map, roads must be "looked into" place and the likely routes selected for further examination. The controlling points and influence points on the routes should be picked out next. A probable selection must be made of the lines connecting these points and afterwards it is necessary to determine if a grade line run from one to the other will fall below the maximum grade adopted. These grade lines should be developed by well-trained assistants, who may work singly in open country but who must work in pairs in dense undergrowth. With clinometers and flags, trial grade lines are run between controlling points and bits of colored cloth tied on the branches as markers.

SNOW CONDITIONS INFLUENCE LOCATION.

After the final route is selected, it is gone over carefully and strips of white cloth are tied on branches of trees to guide the chief of survey party, who runs a preliminary line from flag to flag. If the reconnaissance work is well done, the final location will fall within the cross-sections taken from the preliminary line.

In a large percentage of mountain-road problems, snow conditions materially influence the location of the road. A road located with a southern exposure and exposed to the sun's rays and the warm south winds will be clear of snow much longer than one with a northern exposure. Furthermore, since the snow lies longer on the northern slope and the sun does not reach it to dry it out, the vegetation is heavier, the soil much deeper and the roadbed harder to drain and slower to dry out.

There are a thousand and one other conditions which may affect the road location. In one instance, a mammoth hydraulic placer mine made a certain location possible for one of the California State highways, while a similar mine in another part of the State made the desired location for another road impossible.

AN ART RATHER THAN A SCIENCE.

A hillside location may be preferable to a location through an adobe flat carrying an excess of irrigation water. A high mountain ridge route, open and cool, with plenty of desirable camp sites, though closed a portion of the year by snow, may be preferable to a deep canyon route open the year round, if the principal traffic is to consist of summer tourists and the canyon be narrow and hot, with few places to turn off the road. But if the principal traffic is to be freight, which will be continuous through the winter, then the canyon route is to be preferred. Such considerations, however, may lead the engineer into prophecy. Who can say what the future may bring or what class of traffic should be favored?

From the foregoing it is apparent that the writer believes that the location of highways is an art rather than a science. An engineer with a "good eye for country" and for the beautiful, and equipped with plenty of experience and "horse sense," almost seems to know where a road should go, oftentimes without the need to consider why.

APRIL FEDERAL-AID PROJECTS EXCEED PREVIOUS RECORDS.

FEDERAL-AID road projects approved from one State, Pennsylvania, call for Federal aid to the amount of $1,444,697.54 in the building of nine roads having an estimated cost of $2,516,628.69. A single project in Illinois approved will cost $1,636,445.50 and will receive $818,222.75 of Federal money. An Allegany County (Maryland), project approved, for a concrete road 4.68 miles long, will cost $56,817 a mile. These facts stand out in the April record of Federal-aid projects approved or of project agreements executed.

They emphasize the conclusions arrived at from a study of the March record, that the people have decided to build roads to handle the traffic demands, that the great road-building program predicted for this year is in progress, and that more attention is now paid to the construction of through highways.

April again saw all past records surpassed for Federal-aid projects approved and in agreements signed. Approved statements and agreements together called for $9,559,571.30 of Federal aid for roads having an estimated cost of $20,861,957.96. The number of projects was 174, as against 150 in March. The mileage was 1,443.76 as against 1,270.13.

The increases over the March record are: Number of projects 24, mileage 173.63, estimated cost $3,302,347.89, Federal-aid allowance $2,819,732.13.

The statements approved during the month were 120, with a mileage of 923.53. The estimated cost of this mileage was $16,261,326.51, as against $14,425,114.87 for the projects approved in March, and by far the largest amount yet reached in a monthly record since Federal aid for roads became an accomplished fact. The Federal-aid allowance for these projects was $7,528,550.68, an increase over that for the previous month of $2,066,393.96.

Agreements for 55 projects were signed by the Secretary of Agriculture. All but one were for projects approved in previous months. The Federal aid allowed for these projects was $2,039,614.99 and the estimated cost of the roads $4,626,415.48.

The total Federal-aid agreements executed up to May 1, 1919, number 535, with a mileage of 4,624.83. The estimated cost amounts to $39,059,327.44 and the Federal-aid allowance to $15,614,929.61.

In five States the cost of the new projects approved will be in excess of $1,000,000, while in six other States the estimated cost runs from $576,000 to $908,000. The Federal-aid allowance in these States runs from $296,000 up, in four of them being more than $500,000. In several of them the agreements executed greatly increase the estimated cost and the amount of Federal aid for projects which were considered during the month.

The Pennsylvania projects mentioned, which in their estimated cost and Federal-aid allowance so far tops the record for all the States to date, have an aggregate mileage of 57.81, and nearly all are for concrete roads.

These States follow in the order named in the relative cost of the roads involved in the approved contracts: Georgia, 16 projects, 103.91 miles, estimated cost $1,837,446.21, Federal aid $873,182.05; Illinois, a single project, 65 miles long, estimated cost $1,636,445.50, Federal aid $818,222.75; Ohio, 7 projects, 35.36 miles long, cost $1,241,677.02, Federal aid $387,600; Connecticut, one project, 32.1 miles, estimated cost $1,002,650, Federal aid $501,325; Maryland, 7 projects, 23.93 miles, estimated cost $908,347.77, Federal aid $413,821.38; California, 3 projects, 40.69 miles long, estimated cost $834,239.02, Federal aid $448,969.51.

While Ohio projects come fourth in the estimated cost of the roads the Federal-aid allowance is below that awarded to four States where the cost of the roads is smaller. This happens because in that State the Federal aid asked for is only about 31 per cent of the cost of the roads.

Georgia leads in the number of projects approved, 16, and also in the mileage of the roads covered, 103.91. Pennsylvania and Virginia each had 9 projects approved. The Pennsylvania mileage was 47.81 and the Virginia 41.53, being third and fourth in the list. Pennsylvania's 65 miles put her mileage next to that of Georgia.

The big Illinois and Connecticut projects both ask for 50 per cent of the estimated cost as the Federal aid allowance. The Illinois project is for a concrete road through Grundy, La Salle, Bureau, Putnam, and Marshall Counties. The Connecticut project is for a bituminous road in Hartford and New London Counties.

Idaho comes third in the size of a single project. It is 30.50 miles of earth road in Gooding and Twin Falls Counties, a part of the north and south highway, estimated to cost $649,000 and with Federal aid of $324,500. This large cost for an earth road is due to the heavy grading necessary. Georgia has one project, 15.50 miles of concrete in Chatham County, which will cost $484,774.89, with Federal aid of $200,000.

In the agreements executed during the month Wisconsin leads in number, 14; Texas in mileage, 131.58; and Illinois in Federal aid allowance and in the cost of the roads, $456,043.33 and $917,890.36. The Wisconsin agreements are for roads estimated to cost $630,493.08, with an allowance of $198,625.50.

The Maryland road having the highest average cost per mile, $56,817, will be 4.68 miles of concrete, which will cost $267,905. A road in Warren County, Pa., will cost $44,000 a mile and one in Howard County, Md., $39,853. These also are to be of concrete.

The month's record shows the South moving forward in the road building campaign, with projects showing higher grade construction. Of the 16 Georgia projects approved two were for bridges, 7 for concrete and 1 for either a brick, concrete, or bituminous road, the others being for sand-clay roads. The concrete roads will cost from $30,000 to $32,000 a mile, indicating the highest type construction, for the cost in the South is usually less than that in the North. Louisiana will build a short bituminous macadam road at an estimated cost of $36,377 a mile. Virginia has one bituminous macadam and three concrete roads in 9 projects approved.

FEDERAL-AID RECORD FOR APRIL.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
Alabama	31	Lamar	6.14	Gravel		Apr. 2	$28,071.30	$14,035.65
	40	Marshall	5.60	Macadam	Apr. 10		29,900.31	14,950.15
	44	Dale	.63	Concrete bridge	Apr. 17		69,099.80	34,549.90
	45	do	7.95	Sand-clay	Apr. 12		42,718.50	21,359.25
	49	Limestone	9.97	Gravel	Apr. 19		42,675.60	21,337.80
	50	Coffee	6.41	Sand-clay	Apr. 11		32,161.71	16,080.85
	51	Russell	5.44	do	Apr. 19		32,317.34	16,158.67
Arizona	7	Pinal	12.71	Earth, surfaced in part		Apr. 17	153,436.25	76,718.12
Arkansas	9	Monroe	8.08	Gravel, asphalt carpet coat		Apr. 15	75,183.68	37,471.83
	19	Craighead	5.00	Asphaltic concrete		Apr. 8	102,013.56	30,836.16
	22	La Fayette	15.42	Gravel		do	48,950.95	22,205.52
California	11	Fresno	8.17	Concrete	Apr. 11		211,799.06	105,899.53
	12	Merced	14.90	do	do		251,900.00	125,950.00
	13	Los Angeles	17.62	do	Apr. 25		434,239.96	217,119.98
Colorado	2	Huerfano and Las Animas	64.12	Brick or concrete, gravel		Apr. 12	309,215.71	154,607.85
	16	Morgan	.50	Concrete or bituminous	Apr. 8		10,995.66	5,497.83
	18	Pueblo	1.70	Concrete	do		44,000.00	22,000.00
Connecticut	4	Hartford, New London	32.10	Bituminous	Apr. 26		1,002,650.00	501,325.00
Delaware	5	Kent	5.96	Concrete	Apr. 4		262,240.00	119,200.00
Florida	12	Suwanee	8.70	Sand-clay	Apr. 7		26,367.90	10,000.00
Georgia	2	Chattooga	13.62	Gravel		Apr. 4	98,921.79	49,460.00
	10	Towns	11.66	Graded and drained earth		Apr. 22	67,238.86	33,600.00
	31	Dade	9.80	Top soil or gravel		Apr. 7	59,847.25	29,900.00
	32	Columbia		do		Apr. 17	[1] 10,619.79	[1] 5,326.59
	36	Douglas	12.07	Top soil		Apr. 14	54,443.72	27,000.00
	39	Lawrence		Bridge	Apr. 9		151,723.55	75,861.77
	41	Douglas	6.50	Sand-clay	Apr. 10		41,615.14	20,000.00
	42	Chatham	15.50	Brick, concrete, or bituminous	do		484,774.89	200,000.00
	43	Habersham	5.00	Concrete	Apr. 19		150,672.50	75,336.25
	44	Hall	3.20	do	do		101,751.10	50,875.55
	45	Crawford	7.00	Sand-clay	Apr. 10		25,126.75	12,563.37
	46	Bibb	8.75	Concrete	Apr. 17		309,870.00	154,935.00
	47	Screvens	12.40	Sand-clay	Apr. 26		36,478.48	18,239.24
	48	Clarke	3.50	Concrete	do		100,100.00	50,000.00
	49	Mitchell	13.50	Sand-clay	do		67,298.00	33,649.00
	50	Colquitt	4.32	Concrete	Apr. 29		87,583.65	43,791.82
	51	do	4.70	do	do		108,575.28	54,287.64
	52	Evans	13.20	Sand-clay	Apr. 26		30,062.45	15,000.00
	53	Bibb	2.14	Concrete	do		90,129.60	42,800.00
	57	Butts	4.00	Sand-clay	do		19,976.00	9,998.00
	58	do		Bridge	Apr. 29		31,708.82	15,854.41
Idaho	8	Gooding, Twin Falls	.41	do	Apr. 7		63,217.00	31,600.50
	9	Adams and Idaho	30.50	Earth	Apr. 3		649,000.00	324,500.00
Illinois	[2] 1	Dupage, Kane, Dekalb, Ogle, Lee, Whiteside.	2.79	Concrete and bituminous macadam		Apr. 19	82,570.40	41,285.20
	[2] 1	do	6.51	do		do	201,925.35	100,962.67
	[2] 1	do	4.68	do		Apr. 23	127,838.28	63,919.14
	[2] 2	Kankakee and Iroquois	7.52	do		Apr. 21	244,291.27	122,145.63
	[2] 2	do	7.15	do		Apr. 26	224,061.39	112,030.69
	5	Marshall	1.57	Concrete		Apr. 7	37,203.67	15,700.00
	7	Grundy, La Salle, Bureau, Putnam, Marshall.	65.00	do	Apr. 17		1,636,445.50	818,222.75
Iowa	36	Palo Alto	11.93	Gravel	Apr. 15		85,360.00	22,113.25
Kansas	[2] 2A	Labette		Gravel or macadam		Apr. 29		[1] 25,697.98
	[2] 2B	do		do		do		[1] 35,563.91
	23	Montgomery	9.92	Gravel	Apr. 9		87,628.75	43,814.37
Kentucky	12	Graves	6.13	do	Apr. 14		73,113.70	36,556.85
	13	Carter	16.00	Earth	Apr. 29		158,730.00	79,365.00
Louisiana	22	Rapides	1.66	Bituminous macadam	Apr. 19		60,384.86	30,192.43
	33	West Baton Rouge	13.85	Gravel	Apr. 28		116,527.62	58,115.31
Maryland	13	Prince Georges	5.33	Concrete	Apr. 4		191,730.00	95,865.00
	14	Frederick, Washington	3.51	do	Apr. 15		87,133.20	43,566.60
	16	Howard	5.20	do	do		207,515.00	103,757.50
	19	Wicomico	1.53	do	Apr. 23		55,000.00	27,500.00
	21	Kent	3.03	do	Apr. 12		79,011.57	39,505.78
	23	Caroline	.65	do	Apr. 14		20,053.00	10,026.50
	24	Allegany	4.68	do	Apr. 23		257,905.00	93,600.00
Massachusetts	12	Essex	2.17	Bituminous	Apr. 26		64,372.00	32,186.00
	13	Middlesex	6.49	do	do		222,557.50	111,278.75
Michigan	[2] 4B	Presque Isle	2.85	Gravel		Apr. 15	41,839.38	20,919.69
	28	Branch	5.25	Concrete or bituminous		Apr. 7	146,252.59	73,126.29
	36	Ingham	1.66	do		Apr. 25	61,064.56	30,532.28
Minnesota	2	Chisago		Gravel		Apr. 30		[1] 22,981.40
	9	Sherburne		do		Apr. 23	[1] 4,021.65	
	29	Otter Tail	19.52	do		Apr. 30	103,647.74	45,000.00
	35	Hennepin	5.80	Concrete, brick, or asphalt	Apr. 19		201,118.61	60,000.00
Mississippi	9	Kemper		Gravel		Apr. 21	[1] 11,669.38	[1] 7,683.09
	15	Wilkinson		Clay, gravel		Apr. 25	[1] 15,602.94	[1] 7,849.61
Montana	17	Flathead	9.00	Earth	Apr. 16		17,600.00	8,800.00
	29	Missoula	.54	Gravel	Apr. 19		16,500.00	8,250.00
	39	Ravalli		Bridge	Apr. 8		22,000.00	11,000.00
Nebraska	1	Lancaster		Brick		Apr. 12		[1] 18,705.00
	4	Wayne, Cedar		Sand-clay		Apr. 23	[1] 12,789.21	[1] 6,394.60
	5	Madison, Platte		Earth and sand-clay		do	[1] 11,661.71	[1] 5,830.85
	10	Lincoln		Graded and drained earth		Apr. 26	[1] 4,265.42	[1] 2,132.71
	12	Logan, McPherson		do		Apr. 15	[1] 8,703.42	[1] 4,351.71
	19	Lancaster		Earth		Apr. 23	[1] 2,750.00	[1] 1,375.00
	27	Dodge, Saunders	30.33	do		Apr. 8	64,130.00	32,065.00
	53	Boone, Nance	24.20	do	Apr. 15		53,746.00	26,873.00
	56	Seward, York, Hamilton	49.85	do	Apr. 26		76,505.00	38,252.50
	73	Buffalo	20.00	do	Apr. 16		53,460.00	26,730.00
	81	Dodge	5.94	Concrete	Apr. 28		197,930.15	98,965.00
Nevada	11	Esmeralda	8.93	Earth		Apr. 19	38,423.23	19,211.61
	16	Lander	8.52	do		Apr. 30	28,454.80	14,227.40
New Hampshire	22	Grafton, Merrimack	1.23	Gravel	Apr. 11		9,997.63	4,998.81
	24	Grafton, Hillsborough	1.09	Bituminous	Apr. 10		13,996.62	6,998.81
	25	Merrimack	1.11	Gravel	Apr. 26		7,972.80	3,986.40
	26	do	.79	do	do		9,999.99	4,999.99
	32	Rockingham	1.50	do	Apr. 25		9,948.18	4,974.09
	33	do	3.50	do	do		17,674.53	8,837.26
	34	do	1.05	do	Apr. 29		7,485.14	3,742.57
	35	do	1.00	do	do		12,608.20	6,304.10
	37	do	9.69	Bituminous	Apr. 26		219,211.41	109,605.70

[1] Modified agreement. Amount given is increase over previous estimated cost or Federal-aid allowance.

[2] Agreements are for sections of project.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid allowed.
New Mexico	[2] 1A	Colfax	9.71	Gravel		Apr. 3	$98,622.21	$49,311.10
	18	Eddy	31.00	do	Apr. 4		72,648.40	36,324.20
New York	2	Wyoming		Bituminous macadam		Apr. 29	[1] 29,800.00	[1] 14,900.00
	7	St. Lawrence		do		do	[1] 10,427.89	[1] 5,213.95
	21	Rockland	1.45	Concrete	Apr. 24		52,200.00	26,100.00
	27	Cattaraugus	7.06	do	Apr. 23		224,600.00	112,300.00
	29	Allegany	15.10	Bituminous	Apr. 26		395,700.00	197,850.00
North Dakota	5	Traill	24.87	Earth		Apr. 22	32,078.85	16,039.42
Ohio	10	Wayne	5.00	Bituminous macadam or brick		Apr. 1	150,000.00	50,000.00
	12	Ashland	6.72	Brick		do	213,000.00	50,000.00
	34	Erie	3.04	Concrete	Apr. 2		110,000.00	30,000.00
	36	Columbiana	3.00	do	Apr. 4		84,059.30	35,600.00
	37	Knox	5.10	Concrete or brick	do		200,337.72	50,000.00
	38	Auglaize	6.52	Brick, concrete, or bituminous	Apr. 21		246,320.00	104,320.00
	39	do	7.80	Brick or concrete	Apr. 22		245,000.00	45,680.00
	46	Ashland	3.80	do	Apr. 25		132,000.00	32,000.00
	47	Wood	6.10	Concrete or asphalt	Apr. 29		223,960.00	90,000.00
Oklahoma	6	Okmulgee	15.00	Bituminous	Apr. 12		183,717.60	91,858.80
	7	Muskogee	2.50	do	Apr. 22		84,189.60	42,094.80
	8	Ottawa	15.60	do	do		308,580.25	154,290.12
Oregon	15	Harney	16.14	Gravel macadam	Apr. 15		121,725.71	45,000.00
Pennsylvania	[2] 8C	Erie	4.90	Cement concrete or bituminous concrete on cement base.		Apr. 12	181,997.33	90,998.66
	[2] 8D	do	2.90	do		Apr. 7	117,168.21	58,000.00
	[2] 8E	do	1.70	do		do	64,441.52	32,220.76
	21	Lehigh	6.60	Concrete	Apr. 7		229,300.00	132,000.00
	22	Monroe	4.45	do	do		177,813.90	88,906.95
	24	Warren	7.20	do	Apr. 19		316,800.00	144,000.00
	25	Adams, Franklin	5.70	do	Apr. 16		205,181.19	102,590.59
	26	Elk	5.60	do	Apr. 19		274,093.60	112,000.00
	27	Allegheny	8.26	Bituminous	Apr. 7		363,440.00	165,200.00
	28	Mercer	4.50	Concrete	Apr. 10		198,000.00	90,000.00
	29	Pike	5.60	Bituminous concrete	Apr. 16		246,400.00	112,000.00
	30	Bradford	9.90	Concrete	do		435,600.00	198,000.00
South Carolina	21	Edgefield	8.42	Sand, clay	Apr. 8		35,062.36	17,531.18
	23	Greenville	3.53	Bituminous	Apr. 17		26,762.56	13,381.28
Texas	6	Shackleford	11.12	Gravel		Apr. 4	62,310.25	30,679.81
	30	Jasper	14.73	do		Apr. 12	107,652.94	30,000.00
	35	Gaudalupe	14.58	Bituminous gravel		Apr. 7	70,064.45	34,900.00
	45	Hemphill	15.58	Sand-clay		do	21,046.97	10,523.48
	57	Wilbarger	4.66	Concrete slab		do	108,468.10	46,353.45
	60	Randall	17.65	Sand clay		do	36,955.94	11,800.00
	66	Comal	19.80	Bituminous gravel, or macadam		do	73,886.77	29,750.00
	67	Wheeler	27.98	Sand-clay and gravel		do	63,482.01	31,741.00
	76	Harris	5.50	Shell		do	19,827.50	8,600.00
Virginia	15	Washington	6.75	Earth		Apr. 2	45,291.95	22,645.97
	18	King and Queen, Gloucester, Middlesex.		Graded and drained		Apr. 1	[1] 21,302.66	[1] 10,651.33
	23	Caroline, Essex	4.19	Gravel	Apr. 15		18,824.30	9,412.15
	24	Alleghany	8.03	Slag macadam	Apr. 17		76,725.33	38,362.66
	27	Smyth	5.71	Macadam	Apr. 3		89,621.68	44,810.84
	32	Fairfax	3.27	Bituminous macadam	Apr. 16		63,873.15	31,936.57
	34	Norfolk	5.31	Concrete	Apr. 12		135,910.50	67,955.25
	35	Rockbridge	4.28	Macadam	Apr. 28		53,900.00	26,950.00
	36	Halifax	3.42	Concrete	Apr. 23		79,247.52	39,623.76
	40	Dinwiddie	1.62	do	Apr. 7		36,256.82	18,128.41
	42	King George	5.70	Sand-clay	Apr. 29		37,840.00	18,920.00
Washington	8	Douglas	13.80	Macadam		Apr. 23	127,513.71	63,750.00
	14	Okanogan	2.41	Gravel		do	[3] 16,694.21	[3] 8,278.35
	14	do	5.44	do	Apr. 29		[3] 42,186.32	[3] 21,093.16
	15	do	4.14	do		Apr. 23	[3] 25,326.40	[3] 11,447.98
	15	do	5.07	do	Apr. 30		[3] 36,491.99	[3] 18,245.99
	16	Stevens	13.00	do	Apr. 23		168,821.25	84,410.62
West Virginia	10	Mason		Concrete		Apr. 28	[1] 9,299.55	[1] 38,470.00
	29	Ritchie	5.00	do	Apr. 9		112,040.00	53,500.00
	33	Preston	2.56	Asphaltic macadam	Apr. 28		30,000.00	15,000.00
	34	Monroe	2.00	Macadam	Apr. 29		19,200.00	9,600.00
	35	Monongahela	4.50	Concrete	Apr. 9		88,851.00	44,000.00
	36	Upshur	5.20	do	Apr. 25		128,800.00	28,800.00
Wisconsin	17	Eau Claire and Chippewa	8.80	Concrete or brick		Apr. 1	173,812.56	47,000.00
	33	Fond du Lac	[1] .73	Concrete		Apr. 29	[1] 26,656.39	[1] 8,885.47
	37	Portage		Gravel		Apr. 30	[1] 12,377.26	[1] 4,125.75
	41	Grant	2.15	Earth		Apr. 9	25,797.84	8,599.28
	50	Ozaukee	1.74	Bituminous macadam		Apr. 26	35,399.61	11,799.87
	56	Kewanee	4.41	Gravel		Apr. 23	24,255.27	8,085.09
	60	Green Lake	7.61	Grading and concrete		Apr. 9	44,205.05	14,100.00
	62	Washington	2.90	Concrete		Apr. 15	62,396.58	20,798.86
	63	Waukesha	2.68	do		Apr. 29	52,796.54	17,598.85
	64	Monroe	1.10	Earth		Apr. 9	13,287.25	4,429.08
	66	Richland	2.09	Concrete		Apr. 23	51,089.03	17,029.68
	69	Sheboygan	3.18	do		Apr. 29	62,998.25	20,999.42
	74	Oneida	3.17	Earth		Apr. 23	19,739.32	6,579.77
	79	Walworth	1.28	Concrete	Apr. 8	Apr. 29	25,783.13	8,594.37
	83	Crawford	5.04	Earth	Apr. 12		25,553.00	8,517.66
	84	Jackson	3.20	do	Apr. 16		25,509.00	8,000.00
	85	Oconto	4.36	Gravel	Apr. 15		25,058.43	8,352.81
	87	Buffalo	2.75	Earth	Apr. 16		29,910.54	9,970.18
	88	Sawyer	4.38	do	do		26,897.20	8,965.73
	89	Polk and Burnett	8.22	do	do		44,484.00	14,828.00
	90	Washburn	4.50	do	Apr. 29		25,247.20	8,415.73
Wyoming	23	Niobrara	11.27	Earth	Apr. 7		20,226.91	10,113.45
	24	Lincoln	4.18	do	Apr. 8		19,998.00	9,999.00
	26	do	9.17	do	Apr. 7		30,968.19	15,484.09
	29	Albany	26.87	Gravel	do		73,886.78	36,943.39
	32	Fremont		Two bridges	Apr. 29		27,500.00	13,750.00
Total	174		1,443.76				20,861,957.96	9,559,571.30

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[1] Modification of agreement previously signed. Figures given are increases over those in original agreement.

[2] Agreement is for section of the approved project.

[3] The first figures for projects 14 and 15, Washington, are for agreements executed for the originals previously approved. The second are increases in mileage, estimated cost, and Federal aid allowance in revised statements.

LIFE'S PATHWAY.

By A. D. Williams, Associate Member American Society of Civil Engineers.

HISTORY is the story of man's actions as viewed by various writers as they passed along life's pathway—that road leading from the present back through the ages to the unknown. On this pathway we can find the footprints of greed, avarice, revenge, and other propelling passions, which have found their vent in conquest individually and collectively, which might be described as man's inhumanity to man.

As we stand by this path and look across the plains, vales, and hills as it wends its way back through the centuries beyond vision we see but little written on the many pages telling of constructive achievements and still less touching the hearthstone of the masses.

The pages as they unfold tell of bloodshed, of war, of slaughter, of punishment and depression and extoll as great the instigators of these national crimes, but they have failed to tell us much of the men who have struggled to lift the weight of oppression from the soul of a fellow man. Too much of history is devoted to extolling the great deeds of national criminals. War, horror and destruction, terror and suppression stand dominating the milestones of history. Even the pages of the sacred Book of Books are marked and marred by narration after narration of conquest, war, and oppression. But little is told of the real horrors of prison and the whole course of history is woefully lacking in suggestion of prison reform.

WHO WAS THE FIRST PRISONER.

As to when the first prison was built or who was the first prisoner we have no record. We read that Joseph was cast into an Egyptian prison and confined with the king's prisoners. We are told he was imprisoned upon a false accusation, as some men are to-day, because conditions were not understood and the truth was or could not be produced in court. The prison did not make Joseph worse, neither did placing him there make him a criminal; but Joseph's influence made Egypt better, because he brought forth a message which set a new light in the valley of the Nile and saved Egypt and his home land from famine. It is written "as a man thinketh, so he is," but environments lend color to thought and shade to action.

Cain, the first criminal of which we have record, offers a lesson because the slaying of Abel has cast its shadows down through the ages, but the living lesson posted at that time seems to have been overlooked.

Students of life's evolution tell us that the minute cells which make up the body multiply and reproduce themselves. Cells generated in a body are susceptible to the influences that control that body at the time of their generation. The propelling and controlling power of the human body is the mind and as is the mental condition of parents at the time of the production of these cells so will the strength of the cells be in the life to which they are transmitted. Cells produced in a body brooding with revenge and passion will display their marks in the life that follows, in either a weakened or abnormal state as the new life develops. They may and can be changed by culture and influence, but the weaker and finer the cell the more susceptible to the influences that come its way.

A LESSON FROM THE FIRST GREAT CRIME.

We might draw a picture from the life of Cain. It is fair for us to believe that the conception for that life was about the time the parents, filled with the spirit of remorse and revenge, were banished from the garden. Thus we have a vision of the life, conceived under influence over which it had no control, becoming the first criminal. If we read Genesis (iv 15), "whosoever slayeth Cain vengeance shall be visited on him sevenfold," as a careful student we can see the divine recognition of the weakness in that life and likewise a divine disapproval of capital punishment, and a more careful study of the lesson reveals to us that the Great Judge intended that crime should be punished, but punishment tempered with mercy. Cain was punished for the purpose of correcting his life and not to avenge the crime. His faulty life was to be corrected by proper discipline. A further study of this case reveals the fact that the Great Ruler recognized in the beginning of human life and progress that man himself was the only person capable of judging the sufficiency of the punishment. This case has laid the foundation for prison reform, and the only regret that should be expressed at the present time is that thousands of years and millions of opportunities have been lost, and untold suffering has resulted and will continue for many years by reason of neglect.

The Mosaic laws which form the basis of our present-day statutes are shaded with the impulses of the author's period of banishment. The expressions of "an eye for an eye," "a tooth for a tooth," "blood for blood," and "life for life" are the outbursts of a revengeful spirit. These products of barbarism couching on the penstock of the ancient lawgiver cast their shadows over the peaks of centuries and leave their marks in the valleys of human misfortune.

The most prominent method of execution employed in that period was that of stoning to death. The prosecuting witness cast the first stone, not because of the crime, but in gratification of revenge and satisfaction of the mob spirit.

The world's greatest teacher, who gave us the purest of law, "whatsoever ye would that men should do unto you, do you even so unto them," was the victim of jealous and frenzied court action. The greatest tragedy on the pages of history is that of a trial judge yielding to the demand of a bloodthirsty, self-intoxicated audience. Thus the man who directed that the one in the audience without sin cast the first stone was convicted and condemned to die the most hideous of deaths, not for crime but to satisfy the revenge and passion of a frenzied mob.

THE PURPOSE OF THE PRISON.

Conception of the purpose, a prison, and of punishment has been wrong. A prison should be a moral hospital in which the needs of the morally and socially weak can be treated with character-forming and constructive remedies. These statements are made because we are the creatures of custom. We do things because and as others have done them. The truth of this statement can be found in the location of our roads. In both highway location and dealing with prisoners and prison life we have blindly followed the time-worn path of custom without pausing to make improvements. The census reports will show the truth of this statement. In 1850 we had one prisoner for each 3,442 persons, in 1860 one prisoner for 1,647, in 1870 one for 1,020, in 1880 one for 837, in 1890 one for 760, in 1913 one for 824. These impressive comparisons show us that something is wrong and warn us we should apply scientific remedies to light the pathway along which we are now groping. They say we must collect ourselves, with the determination to blaze a path through the wilderness of custom and precedent to the field of justice, faith, hope, and charity. The problem and its solution lie in the community and the community is dependent on the roads that bring it together.

Crime has a cause, and often we would do a greater work by seeking the cause than by continuing to crush the life of the person who committed the act. Instead of confining unfortunate victims who have transgressed the law merely to justify the law, and inflicting punishment on the body of the individual, we should use imprisonment for only two purposes, while seeking as a community to locate and remove the cause—first, to protect society from the violence of the individual, and, second, by a change of environments so as to correct and reconstruct the life of the prisoner. This basic thought can not be carried out by the old methods of excessive physical punishment and confinement in idleness.

REMOVING A CAUSE OF CRIME.

West Virginia has found and removed one of the causes of the crime. The effectiveness of this removal is found in the following figures. Including the fiscal year ended July 1, 1914, the last year saloons existed in the State, to the present time the prisoners received at the State prison each year and the percentage of decrease is shown here:

Fiscal year.	Prisoners received.	Per cent of decrease.
1913–14	427	
1914–15	388	11
1915–16	335	19.2
1916–17	324	24.1
1917–18	305	28.5

The further proof of this statement is borne out in the records of the 55 county jailers scattered throughout the State. Partially complete report gathered from these jailers showed for the year ended July 1, 1915, the first year in which we attempted to collect such statistics, a total of 198,000 prison days in jail, of which we received 72,550 days' work on the public roads. For the fiscal year ended July 1, 1918, these reports showed 76,726 days in jail, a decrease of 61.2 per cent, and of this number 44,584 days were sentences to work upon the roads, which resulted in 26,098 days actual work; 25,316 days were awaiting trial and the remaining days represented felons waiting transmission to the State prison, Sundays, sick, and bad weather. These figures tell a story of the effect of State-wide prohibition. By it West Virginia in three years' time has lost from prison labor upon the public highways 45,452 days and has added to the usefulness of its citizenship in lieu thereof 121,274 man days.

The prisoner and the prison official are the products of society and while the prison keeper has been looked upon at some times in the past with feelings of resentment the time has come that this feeling must be changed because into his care and keeping must be intrusted lives and souls out of which better citizenship should and must be constructed. There is a better part in every man and when found and cultivated the life can be improved.

A real criminal is an abnormal being and is, in a manner, sick. He needs the treatment that will effect a cure in his case. To do this the right man is needed to care for him. A man to be a leader in a moral hospital must be a moral physician who can diagnose the case before him and then apply the proper remedy. He must have the rarest of judgment, the best of character, the greatest of tact, and the spirit of the truest Samaritan.

REGENERATION THROUGH WORK.

Society during the past has been cruel. The histories of prisoners of war and the cruel treatment of unfortunates who have fallen into the hands of the avaricious and revengeful is an appalling record that shows the failure of man's conception of justice when guided by his own passions in dealing with his fellow man. This damnable spirit was revealed on the plains of Belgium and the hills and vales of France, of Italy, Rumania, and wrecked Russia. Selfish thoughts by individuals and the neglect of society has caused crime and produced criminals. Society has often caused crime by placing temptation before the weak and then persecuting the individual, for which they should be prosecuted.

Placing a man in jail does not make of him a criminal, nor does his detention and punishment free him from crime. A Paul at heart, a Bunyan in action, a Saviour crying "Father forgive them, they know not" has changed the color of prison life. Many a man in prison to-day can be made serviceable to humanity and society if society does its duty by him. The crime is the act and the criminal is the person who bears the feeling that produces the act whether he be the instigator or perpetrator. The man who is a criminal either in or out of jail is the same in the eye of truth and justice. Punishment can not, but regeneration from within will, reform him. This reformation can come only through useful and economical employment. The idle prisoner is a detriment to himself and to society. Idleness is not kinsman to reform. Every prisoner, for his own good, which is the good of society, should be employed.

COMMUNITY PAYS COST OF IDLENESS.

The community pays the cost of every idle man whether in or out of jail, and with this thought in view West Virginia has spread upon her statute books a law requiring every able-bodied man to labor at least 36 hours per week. This has done much to reduce the charges of poverty and likewise improve the entire citizenship.

Then agreeing that for the sake of the community and of the prisoner he should be employed, the next question that arises is as to the kind of employment that will be the most beneficial to all persons interested. The statistics gathered by the writer revealed the fact that of the inmates of the various institutions of this country from 8 to 33 per cent were serving second or more sentences. Answers from the same institutions relating to men that had been worked on the honor system and in the open air range from 2 to 8 per cent, which establishes the fact that open-air employment is the most beneficial from a reformatory standpoint.

The prisoner being a public charge and a debtor to the public for transgressing society's laws, should be so employed as to render the most beneficial service to society. The public road being the common property of the county or State, and Nation as well, offers a class of service in its construction and maintenance that is beyond a doubt the most beneficial. With this thought in view, West Virginia has been employing a portion of her State prisoners since 1914, establishing first a camp in Pleasants County on the Ohio River; second, a camp in Berkeley County, near Martinsburg; and camp No. 3, in Kanawha County, near Charleston, which camp is still in existence.

COST OF MAINTAINING CAMPS.

We have read much relating to the cost of maintenance of prison camps, and to satisfy ourselves during the year 1917 we kept a very careful account of costs under various headings. Table No. 1 shows the cost per meal; also shows the average number of prisoners by month, total meals served, and the movement of prisoners. Table No. 2 shows the cost of guarding and maintaining the prisoners. Table No. 3 shows, by months, the distribution of team cost, including the maintenance of the county's teams and teams hired and maintained by the county.

DISTRIBUTION OF COSTS.

The distribution of the costs was kept under the following headings: Overhead—steam-shovel excavation, hand and scraper excavation; pipe culverts (subheaded), foundation excavation, building forms, placing concrete, placing pipe; bridges (subheading)—foundation excavation, building forms, placing concrete, riprap, unloading and hauling material, clearing and grubbing; placing drain tile, 4-inch and 6-inch; French drain; preparing to and moving machinery; repairing equipment; draining subgrade preparatory for work; coal mining; carpenter work; building and repairing; farm and garden; extra work, not included in unit prices, was kept under the following headings, placing steel, moving fence, building fence, repairing and removing buildings, repairing present and temporary roads, miscellaneous. Total hours, total days, rate, and total dollars were kept on the same chart with lost-labor hours, under the headings of bad weather, Sundays and holidays, sick, camp duty, total hours. This was subdivided each month under the heading of superintendent, foreman, steam-shovel engineer, roller engineer, county teams, hired teams, prison labor, guards, prison-labor overtime. The results showed a total of 36,243 hours prison work and a total of 27,846 lost hours (or, say, uneffective hours), which included 4,808 hours bad weather, 7,991 hours holidays and Sundays, 1,134 sick hours, 13,913 hours camp duty.

The total cost of the camp and all expenses connected therewith amounted to $19,441.34; of this amount $5,039.39 was distributed as camp bills, which included equipment, supplies, etc., for the camp, as shown on Table No. 2, plus the guard salary, $1,092.60, making a total of $6,531.51 shown in the table. The item "pay roll" is shown at $6,685.84. The road bills are shown as $6,624.51, distributed under the headings, reinforcement, $165.99; rental on equipment, $40; sand and gravel, $681.42; pipe, $44.19; cement, $659.80; freight, $42.70; lumber, $397.93; explosive, $12.68; extra, $962.39; coal, $188.61; 4-inch tile, $58.14; team expense, $2,201.20, less a credit of $74.35, leaving $2,126.85; equipment, $747.10; miscellaneous, $496.64. For this we removed 28,883 cubic yards of unclassified excavation at a cost of 40.9 cents, or $11,815.09; 128 cubic yards of foundation excavation for bridges at a cost of $1.48 per cubic yard, or $2,855.29. This includes 263.57 cubic yards of concrete, costing $10.12 per yard, 74.7 feet of 12-inch pipe in place, including 113 yards of excavation, $964.09, making the excavation cost 90½ cents per yard and the pipe $3.24 per foot; 28 yards of excavation and 17.87 feet 18-inch pipe culvert cost $321.16, or $1.30 for excavation and $5.04 per foot; 215 feet French drain cost $52.65, or 24½ cents per foot; 768 feet 4-inch subdrain, $170.42, or 22 cents per foot; 89 feet 6-inch guard rail, $10.27, or 11½ cents; 22

TABLE No. 1.

Months.	Average number of prisoners.	Total number meals served prisoners.	Total number meals served foreman and visitors.	Grand total of meals served.	Number prisoners returned to penitentiary.	Number sick days.	Number released.	Number of escapes.	Number prisoners received.	Number prisoners captured.
January	15	1,546	84	1,630	3		2		20	
February	15	1,344	68	1,412		2				
March	14	1,389	91	1,480	3		2		4	
April	15	1,458	108	1,566						
May	15	1,449	134	1,573	3		3		6	
June	14	1,376	152	1,528		5	2	1	2	
July	12	1,241	266	1,517		21		1		
August	22	2,359	236	2,595	1	57	5	4	19	
September	21	2,095	231	2,326	1	2				3
October	23	2,309	195	2,504	1	24			10	
November	28	2,730	230	2,960		7	2	1	2	
December	24	2,399	164	2,563	4	8	2			1
Total		21,695	1,959	23,654	16	126	18	7	63	4

Total cost of food, $3,303.22. Cost per meal, $0.1396.

TABLE No. 2.—*Cost of guarding and maintaining prisoners, by the day and in total, at West Virginia State road camp No. 3.*

[Covering the year 1917.]

	Total.	Guards.	Miscellaneous.	Food.	Equipment.	Clothing.	Tobacco.	Garden seed.	Transportation.	Rewards.	Coal.
January	$447.46	$91.05	$3.25	$158.94	$6.79	$58.68	$11.40		$97.10		$20.25
February	351.13	91.05	8.55	186.01	15.85	13.00	9.52		2.40		24.75
March	382.72	91.05	7.53	203.82	3.30		9.52		59.75		8.75
April	355.67	91.05	20.00	188.19	9.68	22.55	20.40	$12.45	3.35		18.00
May	429.19	91.05	36.60	201.03	1.60	37.50	11.41	2.40	46.70		.90
June	435.76	91.05	6.62	273.54	12.19	38.10	13.01	1.25			
July	352.16	91.05	3.90	206.31	20.24	8.75	19.86	.30	1.75		
August	771.40	91.05	32.40	410.07	19.40	51.35	28.00	3.35	135.78		
September	816.74	91.05	15.60	357.35	25.40	107.59				$229.75	
October	652.24	91.05	48.05	367.53	23.90	92.09	29.62				
November	778.50	91.05	41.60	539.98	15.00	14.73	17.49		58.65		
December	717.54	91.05	28.32	300.87	48.66	129.44	23.91		45.29	50.00	
Total	6,531.51	1,092.60	252.42	3,393.64	202.01	573.78	194.14	19.75	450.77	279.75	72.65
Inventory	329.52			90.42	57.36	251.74					
Grand total	6,131.99	1,092.60	252.42	3,303.22	144.65	322.04	194.14	19.75	450.77	279.75	72.65
Total days prisoners	7,232										
Cost per day	.8465	.151	.035	.456	.02	.0443	.027	.0026	.062	.0386	.01
Effective prison days	4,027										
Cost effective day	1.5227	.2717	.0627	.82	.036	.08	.0482	.0049	.1117	.0695	.018

TABLE No. 3.

January	$100.11	$15.65	$84.46						31	6	186
February	79.90		69.90	$6.00	$4.00				28	6	168
March	64.37		59.67	2.80	1.00	$0.90			31	6	186
April	123.86	.60	105.26	12.00	6.00				31	6 [1] 8½	186
May	153.55	1.40	117.60	10.55	1.00		$23.00		30	[1] 9½	255
June	159.63	7.25	152.38						30	9	270
July	281.89	74.35	173.62	12.00			15.25	$6.67	31	9	279
August	260.50	2.65	250.05	5.90		1.90			31	9	279
September	221.95		220.31	.90		.74			30	9	270
October	271.19		261.19	10.00					31	9	279
November	226.68		200.62	10.00			16.06		30	9	270
December	257.53	25.20	187.33	21.00	24.00				31	9	279
	2,201.16	127.10	1,882.39	91.15	36.00	3.54	54.31	6.67			2,907

[1] Months.

Feed cost per day, per head, $0.648. 879.55 effective working days, at $2,201.16, equals $2.5026 per team per effective day. Total cost teams, total effective working days, 879.55; cost per day, $2.5026.

yards of riprap, $55.91, or $2.554 per yard. Extra work, $2,605.41; engineering, $596. As a matter of comparison these quantities were figured on the price given by the court for a similar piece of work on the opposite side of the river. Using the contractors' items of cost, the total cost would have been $26,847.68, or a net saving to the county of $7,642.34, or 39 per cent.

PENITENTIARY SELF-SUSTAINING.

The legislature of West Virginia has for some years treated the penitentiary as a self-sustaining institution and made no appropriation for its maintenance, so the State road department in conjunction with the board of control and the county courts have worked out plans to suit as near as possible each separate condition. When camp No. 1 was established March 23, 1914, the State undertook to guard, feed, clothe, and supply the labor to the county at 75 cents per day. On this it lost money. On May 20, 1914, camp No. 2 was established on the same basis at a per diem cost of 82½ cents per day. This venture likewise was not satisfactory and proved expensive to the prison department. Camp No. 3 was established on the basis of camp No. 1 on July 6, 1914, and so operated for a period of time. Then the county agreed to assume all of the cost of maintenance, including transportation and guarding, and to arrive at some figures on which we could base our future actions the heretofore explained accounting system was installed.

On the first of the calendar year 1918 it became necessary to change the remuneration to the State, because of the high cost at the penitentiary, and a new contract was made at camp No. 3, whereby the county bears all of the expense and pays the State 75 cents per day. Of this 25 cents per day is returned by the State to the prisoner, who in addition thereto receives 15 cents per hour for all time over 9 hours per day. Camp No. 4 was established March 13, 1918, with 30 men as a minimum. The county of Fayette pays all of the costs and pays the State $1 per day, of which the State pays the prisoner 25 cents and the county pays the prisoner 15 cents per hour for all overtime. Camp No. 5 consists of 50 men working from the penitentiary—the State boarding and clothing, the county furnishing transportation and guards. For this service the State receives $2 per day, of which 25 cents per day and overtime is paid to the prisoner.

FOURTH OF CONVICTS ARE TRUSTIES.

In order to take care of some railroad improvement needed in the Benwood yards, camp No. 6 of 50 prisoners is worked direct from the penitentiary for the Baltimore & Ohio Railroad, the railroad paying $2.85 and furnishing the men their dinners or noonday meal. The State pays the prisoner 25 cents per day of this $2.85. We have at the present time a total of 170 men working in the public-road camps, and 50 men on the special railroad work, making a total of 220, or over 25 per cent of the prison population, working as trusties or on the honor system. The warden, the State board of control, the governor, and the State highway commission are pleased with the results thus far obtained. We hope to do more.

Concluding, the prisoner should be given employment on the public road because it is the most beneficial, both to him and the community. He should be treated with all the confidence that possibly can be imposed. He should have some compensation for his labor; in addition we feel he should have consideration for good behavior, and to this end we grant him five days per month in addition to what the prison rules allow, that being one day per month for each year of the sentence. Everything possible should be done to instill within the man a confidence and to help him construct a substantial moral fabric within his life. Beyond constructing the prisoner into a substantial and useful citizen and constructing public highways by the proper direction of his labor, society's first and greatest duty is to remove as fast as possible whenever and wherever possible the environments that tend to make crime.

Arizona One of the Pioneer States to Utilize Convict Labor on Its Roads and Bridges.

By B. M. ATWOOD, State Engineer.

THE STATE of Arizona has been one of the pioneers in the use of convicts on the construction of State roads and bridges. Such labor has been in use in Arizona from the year 1909 and has been used on practically all types of road construction, including heavy mountain work, light grading across desert areas, the construction of reinforced concrete bridges and culverts, and in the production of crushed stone, concrete pipe, and other road materials.

A force of convicts from the State prison was engaged in the construction of a large reinforced concrete arch bridge across the Gila River, south of Clifton, and in the construction of the highway

TUCSON-FLORENCE HIGHWAY, PIMA COUNTY, ARIZ., CONSTRUCTED BY PRISON LABOR, SHOWING CONCRETE PAVED FORD.

leading from Clifton over this bridge and through the mountain pass on the south side of the Gila River to Solomonsville. Cochise County also utilized a force of 40 or 50 county prisoners who had been given a jail sentence for some misdemeanor. These county prisoners were put on the construction of a reinforced concrete arch bridge and also the construction of the highway crossing it and connecting Tombstone and Bisbee.

A COUNTY CONVICT CAMP.

These two prison camps are not handled in precisely the same manner but both give satisfactory results. Near Bisbee, in Cochise County, there are between 45 and 55 men, the number fluctuating from time to time. These men are housed in a large bunk house surrounded by a high barb-wire fence stockade, closely wired and so constructed as to discourage thoughts of going over the top. Large gasoline lamps are used at night in order to thoroughly light up the stockade and the surrounding country, while guards are on duty at the two opposite diagonal corners of the stockade in a raised tower.

In each camp strict adherence to the daily program is required, the time for retiring being 9 o'clock and that for rising 6 o'clock. Promptly after the completion of the breakfast the men are loaded into autotrucks, leaving camp in time to start the work at 8 o'clock. Each separate gang is in charge of a foreman, who is assisted by armed guards accompanying the men wherever they go on the work. Dinner is carried to the gangs on the road in autotrucks, unless the men are working close to camp. The length of the working day is strictly confined to 8 hours, the legal workday in Arizona for free labor.

WELL ORDERED STATE CAMP.

At the Clifton camp, in Gila County, where the convicts from the State prison are worked, the men are housed in large tents with bunks arranged in two rows of two tiers each extending down the sides of the tents with an open passage extending down through the middle of the tents. In both camps each man is provided with a pillow, two blankets, and a mattress with the necessary linen. Absolute cleanliness is insisted upon in and around the bunk house, tents, and stockade.

There is one tent for the camp barber shop, although the barber is required to perform other duties in addition to those of his trade. The stockade is equipped with a concrete toilet and good shower bath with proper sanitary arrangements. There is a dining tent in the Clifton camp 18 by 50 feet, having two long tables and benches seating 100 prisoners. Connecting with this tent is the kitchen tent 14 by 16 feet in size, and the baking is done in still a third tent adjoining the kitchen.

CONVICTS ARE PROPERLY FED.

Careful attention is given to the matter of proper feeding. It has been found that failure to furnish satisfactory food will cause trouble among the men quicker than any other single item. In both camps the cooks and assistants are selected from among the prisoners themselves. The rations are varied and the best effort is made to prepare them and serve them in an attractive manner. While working out in the desert regions the difficulty of obtaining fresh fruits and vegetables is so great that at times it is necessary under these circumstances to replace fresh fruits and vegetables that would otherwise be served by canned goods and dried fruits. An effort is always made, however, to obtain the fresh articles in place of all forms of canned goods.

At the Clifton camp, where a force varying from 90 to 100 men are worked and fed, the following articles are included in the weekly diet:

For breakfast the men are served corn, bacon, mush, sirup, bread, and coffee. Twice a week hot cakes are added.

For dinner there are potatoes, beef stew, beans, bread, dried fruits, and coffee.

Supper consists of either steak or stewed beef, potatoes, rice, macaroni, canned sweet corn, peas, or tomatoes alternatively, bread and coffee.

For Sunday breakfast they get ham and eggs. Twice each week either pie or cake is served with the dinner, and three times each week they are furnished with smoking or chewing tobacco.

Complaint about the food is seldom heard and the men are found to be gaining in physical condition from the time they reach the work until they leave it.

The following table shows the amount of food allotted to each convict during a month's time in the Clifton camp:

	Pounds.		Pounds.
Flour, wheat	12	Fresh beef, pork, or mutton	23. 5
Flour, milo maize	1. 6	Flour, barley	2
Rolled oats	1. 7	Corn meal	22
Sugar	3	Macaroni	. 8
Prunes	1. 5	Vermicelli	. 2
Canned peas	2. 4	Dried apples	2. 0
Dried peaches	. 1	Dried apricots	4. 0
Canned tomatoes	4. 4	Canned corn	6
Cottolene	4	Bacon	5. 2
Beans	1. 6	Ham	1. 6
Onions	3. 7	Lard	1. 5
Velva sirup	5. 0	Condensed milk	3. 9
Coffee	2. 6	Potatoes	17. 0
Rice	1. 7	Eggs	17
Cheese	1.0		

THE EFFICIENCY OF THE WORK.

During the nine or more years Arizona has been employing convicts on State highways and bridges there has been a wide variation in the character of the work done and in the satisfactory features attending it. There have been times during this period when the work done by convict labor has proven expensive, when it has been inefficient, when the convicts have shown poor discipline, and when the camps have been prone to show a big percentage of men idle and undergoing disciplinary detention.

It has been notable also that when the work has been going badly the percentage of escapes at the same time has often been high, and the costs have necessarily gone up as the efficiency has fallen.

At other times the convict camps have been a source of great satisfaction and have shown low costs, high efficiency, a praiseworthy disposition among the men, and generally healthful and satisfactory results.

The general conclusion that has been reached in regard to convict labor is that such labor is capable of producing work of good quality, both in highway work and in the construction of reinforced concrete bridges, that costs are low and escapes few. It appears, however, that such convict labor is more dependent on the quality of its leadership than is free labor, and that a convict camp under poor management may easily become a source of great annoyance, of danger to the public, of loss in money, and may fail to produce any work of value to the State.

SOURCE OF PROFIT TO THE STATE.

I have no hesitancy in saying that convict labor may be made a source of profit to the State. That such labor can be so led as to produce the best quality of work; that a convict camp may be so managed as to be reasonably contented, cleanly, healthful and of assistance to the men in improving their moral and mental condition; and, furthermore, that whenever convict labor fails to achieve such results the methods and personnel of the management should be held accountable for the failure rather than the quality of the labor that is used.

This broad statement is not intended as a personal criticism of anyone who may fail to obtain satisfactory results in the control of prison camps. As a matter of fact there are relatively few men who are gifted with the quality of leadership required in handling this class of labor. Somewhat different qualities are required in dealing with a mass of prison labor than with the average free labor camp.

The mental endowment and training of the average convict laborer is below that of the average free laborer and, speaking generally, convict labor can not be developed so as to give the most satisfactory results in the handling of high-class machinery or in the control of other laborers. In order to obtain satisfactory results it has been found advisable to employ paid labor on such machinery as is in use on bridge and highway work and to employ paid labor exclusively for foremen.

COSTS TWO-THIRDS FREE LABOR.

From the results obtained in Arizona in a period of nine years, we feel warranted in stating that the cost of work done by convict labor under our laws

PHOENIX-TENEPE HIGHWAY, MARICOPA COUNTY, ARIZ., CONSTRUCTED BY PRISON LABOR.

has been approximately two-thirds the cost of similar work under the day labor system. In comparing work done by paid labor under our own organization with work done under contract, we are inclined to the opinion that work may be done by prison labor for about two-thirds the cost of the same work under the contract system, provided the contractor carries on his work in an equally satisfactory manner and that his bid is a reasonable one, satisfactory to himself.

There is no doubt that the moral and physical tone of the men employed on State highways has been much improved by taking them away from the surroundings of the State prison and keeping them actively employed in the open on work that is interesting, more or less arduous, and healthful in its nature. The benefits derived along these lines by the prisoners themselves are worthy of consideration and undoubtedly can be greatly increased.

CONSTANT WORK OR RECREATION.

Too much importance can not be placed upon keeping prison labor constantly employed either in some form of useful work or some form of healthful recreation. Each prison camp in Arizona has, as a part of its regular equipment, baseball bats, balls, and such facilities in the way of a baseball field and stands as it may be possible to provide, also such games as chess, etc., that tend to develop and improve the mental qualities, and in addition a small library with suitable magazines, books, etc.

The importance of providing proper recreation is so great, we believe, that when recreation can not be furnished the men they should be assigned to different forms of work on different days, in order to vary the monotony of their employment. It is better to insist on long hours of employment than to allow idleness without proper amusements. It need hardly be said that the amusements should be insisted upon in a regular manner quite as much as the work.

GIVE REWARDS FOR EFFICIENCY.

Some systematic reward should be arranged for the convict laborer who performs his work to the complete satisfaction of the men in charge. This reward may be either in the form of scrip that can be exchanged for fruit, candy, or such other things as may be available at the commissary, or it may be, in the form of a reduction in the length of his sentence, or possibly in the form of funds held in trust for the benefit of the convict himself or his dependents.

The reward should be of such a nature that those convicts who cooperate with the management of the camp shall clearly appear to benefit from such reward more than their fellows who fail to render the service and obedience required. In Arizona the superintendent or engineer in charge of the prison camp makes a report to the State engineer at the end of each month, recommending for parole or commutation those whose services have been such as to entitle them to this reward. The State engineer in turn makes his recommendation to the governor and the parole board.

Those contemplating the use of prison labor should visit some properly conducted camp operating with

TOMBSTONE-BISBEE HIGHWAY, COCHISE COUNTY, ARIZ., CONSTRUCTED BY PRISON LABOR.

such labor. They should be prepared for many disappointing instances in connection with its employment and much harsh criticism from those not familiar with all the facts. We feel certain, however, that taking the average results over a period of years they will find that it is no mistake to use the prison population as far as it is available for public work.

Building Oklahoma State Roads With Convict Labor.

By **H. C. SMITH**, Assistant Highway Engineer State Department of Highways.

IN 1915, the State legislature enacted a law which made it possible for the board of affairs in conjunction with the highway department to use State convicts for the purpose of building State highways. As petitions from counties for convicts for this purpose are granted by the board of affairs on the recommendation of the State highway department, it has been possible to use the convicts to build especially difficult stretches of road which proved to be too costly for the counties to themselves handle, thus completing through State roads that would otherwise have links that could not be constructed as soon as the rest of the system.

The method of administering this labor has been as follows: Any county desiring the use of convict labor must make application to the board of affairs to have it establish a convict camp to construct a given section of road within the county. This application is considered and recommendations are made by the State highway department, and largely upon the basis of this recommendation, the board of affairs makes its decision.

When convicts have been granted to a given county, the State furnishes all teams and tools and allows the county an amount of money for the rations of the convicts equal to what it is costing the State at that time for the rations of the men kept at the penitentiary. The county has to provide for any excess cost of rations as well as feed for teams and furnish fuel and explosives.

On May 20, 1916, the first convict camp was established, and since that time there have been 14 camps in all. Late last year there were only eight camps at work, due largely to the fact that the labor had been shifted to agricultural and other urgent work.

The excess cost of rations has varied from 1 cent per day to 26 cents, which represents the daily cost per man to the county.

The camps that have been established have varied in size from 15 to 100 men, which required at least

2 employees and more in the larger camps. Where the men have not been trusties, additional guards are required, all of which expense is borne by the county.

In general, the convicts are used on mountainous sections of road where the cost of labor is the big item in the construction cost. However, it has been possible to handle the convicts in concrete work on small bridges and culverts, by employing a competent concrete worker to act as foreman.

The roads built have been very satisfactory, having been constructed according to plans and profiles which had been approved previously by the highway department.

Florida Has Efficient State Convict Road Force; Plans To Use It on Higher Type of Construction.

By **WILLIAM F. COCKE**, State Road Commissioner.

PRISON labor has, to some extent, been utilized in Florida for road work, almost from the time the State was organized. Howe for many years all of the State, or felony, prisoners and a very large per cent of the county, or misdemeanor, prisoners were leased out to individuals or corporations to be worked in sawmills and turpentine camps.

Not until about 1910 did the counties generally begin to make use of their misdemeanor prisoners for road work, and no State prisoners were worked on the roads until 1915, when the State legislature passed a law allowing the several counties to lease from the State such State prisoners as were not of the first grade and, therefore, not sought after by the other lessees. About the same time the State purchased a large farm on which were placed all of the female prisoners and such male prisoners as were not eligible for the lease.

A late prison census showed there were approximately 1,000 able-bodied male State prisoners and approximately 1,200 county or misdemeanor prisoners. Nearly all of the county prisoners were then employed on road construction and maintenance and approximately 450 State prisoners were also thus employed. The balance of the able-bodied State prisoners were leased out.

PLANNED FOR STATE CONVICT ROAD FORCE.

In 1916 the State road department, having been created by the legislature of the previous year, began to lay its plans for the organization of a State convict road force, which would eventually utilize all of the able-bodied State prisoners. This movement met with strong opposition from the advocates of the large prison farm where all State prisoners of every class would be employed in agricultural work. However, the legislature of 1917 did create a State convict road force to be worked under the State road department, and provided that not in excess of 300 of the lower-grade State men should be furnished same after the needs of the farm and the several counties had been met. So far the greatest number employed on the State convict road force has been 160. These have been worked in 5 separate camps scattered over the State.

These prisoners have been housed in cages mounted on wheels. These cages are 24 feet long, 7 feet wide, and 7 feet high at the eaves and will accommodate 18 men each. While authorized by the law of the State, the writer considers these cages very bad for both the physical and moral welfare of the prisoners.

The State road department planned the construction of a portable knock-down building built of two by fours, latticed and bolted at each intersection. The rules of the State prison board do not allow the chaining of a prisoner in the sleeping quarters, so the building must necessarily be strong enough to confine the men at all times. Should this type of building prove a success a more detailed description, accompanied by plans and photographs, will be furnished at a later date.

COST OF MAINTENANCE.

Since the establishing of the State convict road force in 1917 the cost of feeding, clothing, and guarding has increased so rapidly that it would be hard to determine a fair average price per man, but inasmuch as the price of labor has about kept pace with the cost of living, it would be safe to assume that the total cost per man has not exceeded 50 per cent of the current wage for the same class of labor.

The prisoners have been employed chiefly on grading and sand-clay construction. They have also been used to some extent on the higher types of surfaces. The accompanying picture shows the men laying paving brick. It is expected very shortly to use prison labor on concrete surface and also asphalt laid on concrete base.

Owing to the character of men furnished for the State convict road force a comparatively small per cent of trusties have been available. Although, the best grade of prisoners have not been provided and other conditions have been unfavorable, the success

CONVICTS LAYING BRICK ON A FLORIDA ROAD.

of the State convict road force is assured and it is expected that the lease system will be entirely abolished and all of the able-bodied State prisoners placed on road work.

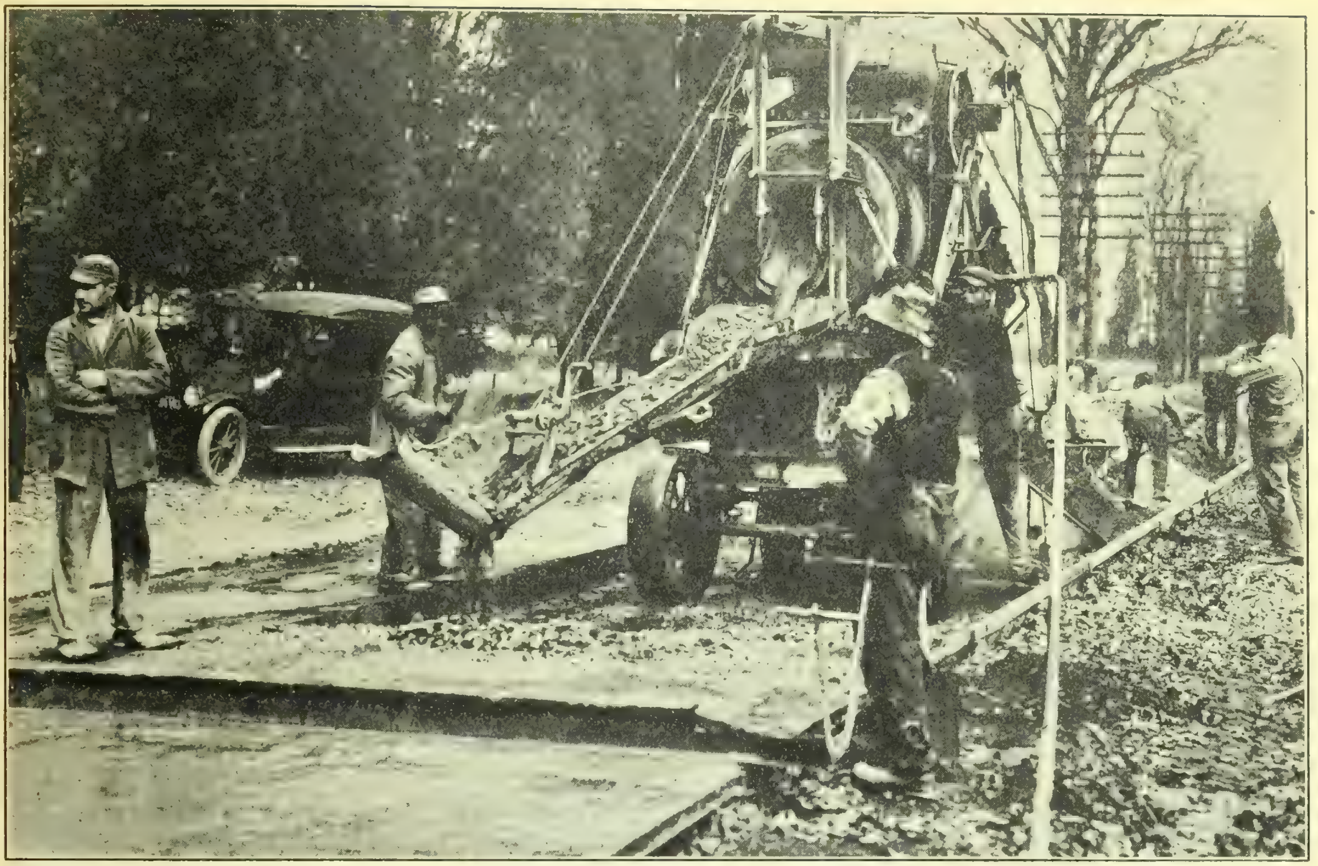
Some of the counties have very efficient and well-equipped road forces. A few continue to lease out their misdemeanor prisoners but these are the exception.

Maryland's Governor Believes Work on Roads in Line with Ideas of Proper Treatment of Convicts.

By Gov. E. C. HARRINGTON.

IT SEEMS to me that no matter how important the question of utilizing to the utmost all labor that is in any way available, the questions we are now considering have a more far-reaching importance, if that be possible, than that of supplying imminent needs, for they tend to the solution of the grave problems that vitally affect thousands of unfortunate men who are continuously passing through our penal institutions and who will be better or worse at their release therefrom through our dealings with them there. The State, which through the power and majesty of law assumes the right to confine and punish, assumes at the same time a great responsibility, which, however lightly it may have ignored it in the past, in this enlightened day must be gravely considered, to the end that the State may discharge its duty in conformity not alone with justice, but having primarily in mind the best interests of those whom it seeks to reform and to reinstate in society, as well as to punish. The manner in which the State discharges these important duties and effects these various results furnishes evidence of its progressiveness and efficiency, or the reverse, for its methods in dealing with its convict classes and with its unfortunate poor and afflicted wards furnishes an unmistakable gauge of the refinement and intelligence of its citizenship and of those who are charged with the responsibilities of government.

Gone is the day when these responsibilities could be ignored, and with that day too recedes into the past the unspeakably cruel and inefficient methods of torture, of solitary confinement, of neglect, of willful and arbitrary corporal punishment which were formerly inflicted upon those whom the State sought only to destroy or to punish, with no thought



MARYLAND CONVICTS MIXING CONCRETE.

of reforming or of reinstating them in society. However, a new day has long since dawned, and the light which has followed the dawn has pierced even the dungeon walls, and with the light which has been diffused through the darkness of prison cells have gone bright rays of hope which have dispelled the gloom of human minds and which have struck to life again thousands of our despairing fellow men.

THE PUBLIC AND THE CONVICT.

The attitude of the public, and especially the attitude of those entrusted with the administrative and executive functions of government, Nation, State, or municipality, toward those who are punished by imprisonment for some violations or infractions of the laws of the land has, indeed, undergone a wonderful change during the past decade.

Our penitentiaries and houses of correction have been looked upon in the past as places of punishment alone, and the moral or physical welfare of the criminal, much less his possible reformation and restoration as a useful member of society, has not received until within recent years that serious thought and consideration which, in my opinion, the possibilities for wonderful service toward the salvation and redemption of these offenders justify.

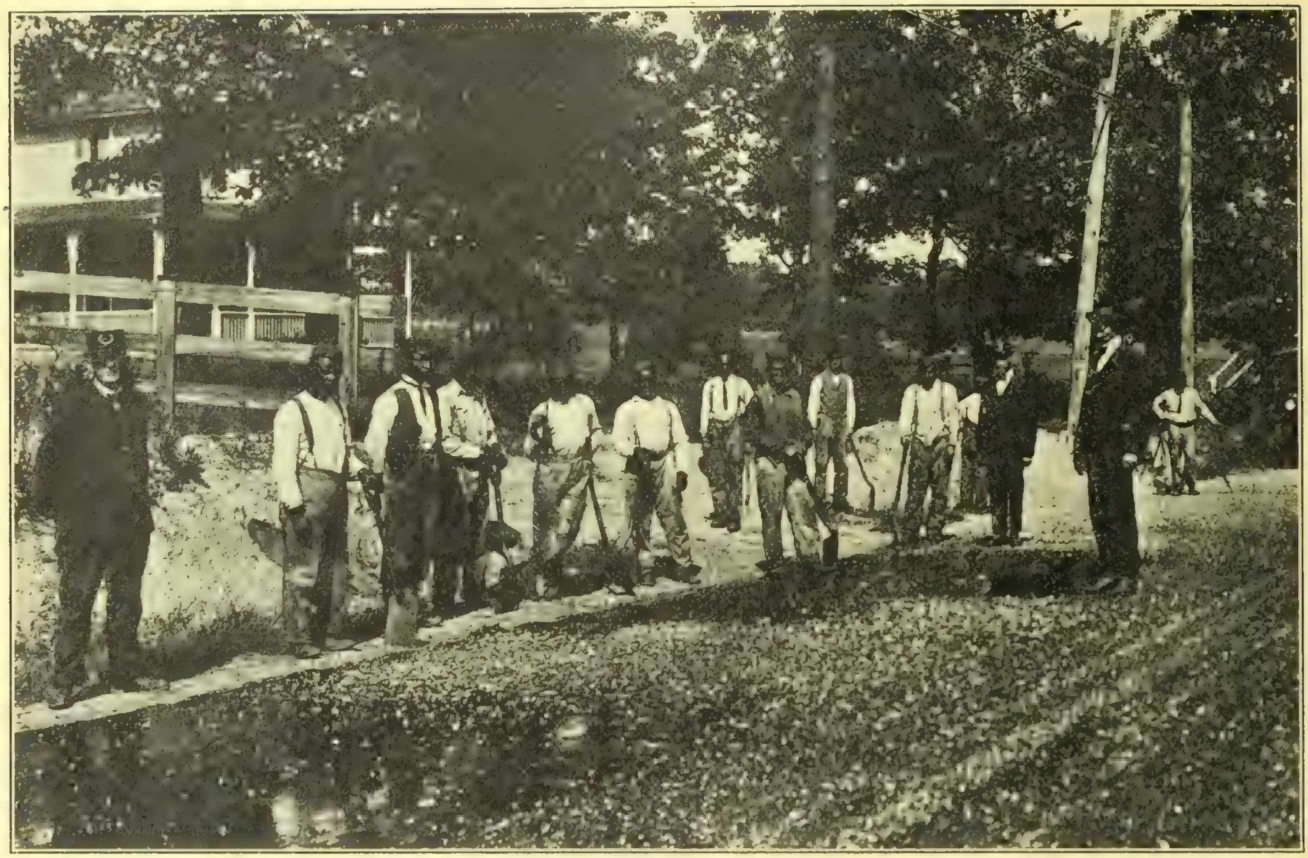
It is now fully recognized that environments make some criminals just the same as environments keep others straight, and that individuals differ largely because of differences of opportunity for education, for social advantages, and for proper livelihood.

Therefore, there has arisen a public demand for the giving to all these convicts whose antecedents, whose records for good behavior at the places of confinement, and whose youth or previous conduct justifies the hope for their redemption another chance or opportunity in life to make good.

THE PAROLE SYSTEM FAVORED.

With such objects or purposes in view the legislatures of different States have passed laws giving the power to a pardoning board, or board of prison parole, to pardon or parole, or upon their recommendation for the governor to parole in all cases, which, in the opinion of the board or the executive, there would appear to be reasonable grounds for the reformation of the criminal and his restoration as a useful or desirable member of society.

I believe the parole should be liberally exercised. In our State we have an advisory board of parole, who investigate all applications for parole or pardon and send the result of their investigations, together with all papers or records in the case, to the governor, with their specific recommendation and their reasons therefor, and the governor approves or disapproves, the power of pardon or parole after sentence, under our constitution, being placed in the hands of the governor alone.



CONVICTS SPREADING CHIPS FOR SURFACE TREATMENT ON WASHINGTON-BALTIMORE ROAD.

The parole board makes no recommendations until the convict has served one-third of his sentence. With the power of parole in the hands of the court before sentence, as the certainty of punishment and not its severity is a deterrent of crime, the fact that all persons who receive sentence to imprisonment have to serve one-third of their time gives a uniformity that means a greater sense of justice.

But in the practice we found that these prisoners who were the better informed or who had more influential friends or who were in a position to employ counsel were the cases which received consideration, while others less fortunate, but equally deserving, went unheard. So the last session of the legislature passed a law requiring every case to be investigated and every case heard at least every second year of their sentence, whether application was made therefor or not. I believe thoroughly in the parole. Since I have been governor of Maryland I have paroled about 225 cases, and there have been but 15 cases, or about 7 per cent, who have violated their parole, a remarkable showing overwhelmingly justifying the parole system.

One thing we always do which I deem particularly important and that is to rearrest all violators of the parole and that they are required to serve out the full time, or at least one properly punishing them for their failure to respect the parole.

WORK NECESSARY FOR CONVICTS.

But not only is it necessary to give the criminals another chance, if that be possible, but it is equally as important to see that the conditions and circumstances which surround them while in prison shall be of such a character that would be in the highest conducive to their welfare, to their proper protection, to their reformation, if possible, and to the advancement of their future lives, when they are returned, either by pardon, parole, or the ending of their sentence, to take their places in society once more.

That the convicts should not remain idle has always been universally conceded. But in his employment the different institutions have been until lately more interested in the revenues accruing therefrom to their respective institutions and somewhat regardless of the health and welfare of the convict himself. Hence has grown up at these institutions what is now admitted on all sides to be an iniquitous contract system for prison labor with the contractor interested in nothing but getting the most work and the most hours per day from the convict labor at the lowest cost he can. That the contract system shall go as soon as possible is now being promulgated from every authoritative source. But what shall take its place are the questions to be solved.

TWENTY-FOOT CONCRETE ROAD, WASHINGTON-BALTIMORE HIGHWAY, BUILT BY MARYLAND CONVICTS.

CONVICTS ON MARYLAND ROADS.

The extra session of the legislature of Maryland authorized the State roads commission to call upon our board of prison control for the use of as many of the convicts as could be used by it in the building and maintenance of our State system of public roads, and now there are about 200 employed from the house of correction and 100 employed from the Maryland Penitentiary upon the public roads of Maryland.

The prisoners remain under the personal supervision of the State board of prison control and every arrangement is made for the proper care and protection of the convicts, and a very large part of the daily pay is paid over for the benefit of the convict himself.

The convicts themselves are delighted with their open-air work and their average health has been much improved.

Illinois Uses Convicts In Preparing Material.

By CLIFFORD OLDER, Chief Highway Engineer.

IN 1913 the Illinois Legislature passed an act authorizing the employment of convicts and prisoners in the penal and reformatory institutions of the State in the preparation of road building materials and in working on the public roads.

The prisoners and convicts in the penal institutions of the State of Illinois have been used in the preparation of road building material since 1906. Crusher plants were established within the walls or adjacent to the penitentiaries at Joliet and Menard. The output of crushed stone from the two plants varies from 40,000 to 154,000 cubic yards per annum. All crushed stone thus far prepared has been furnished free, f. o. b. cars at the penitentiaries to county and township road officials making application for it and agreeing to pay the freight charges. All applications for such material are handled through the State division of highways.

SEVEN CAMPS ESTABLISHED.

Since 1913 seven convict camps have been established in different communities of the State for the purpose of constructing earth, gravel, and macadam roads. Experience shows that these camps have been a success from both the economic and humanitarian standpoint.

All road camps thus far established have been recognized as "honor camps," and only "select" men were chosen for them. The compensation for the convicts in camps thus far established has been 50 cents per day straight time, and each convict secures one day off of his sentence for each three days employed in a road camp. The 50 cents per day per man has been used in feeding and housing the men. There have been no guards employed except one night watchman at each camp and one custodian having general supervision over the men. There have been no escapes from the road camps. The road officials have been required to pay for the two men in addition to the 50 cents per day per convict. No convict road camps have been established since 1916.

Complete arrangements have not been made for establishing camps this season but tentative plans contemplate that a sufficient wage will be set aside for each man which will not only take care of his keep but will give the prisoner something that may be sent to his immediate family or be credited to his account for his use upon completion of his sentence.

EXTRA MONEY INCENTIVE TO MEN.

Experience in the use of convicts in construction camps has shown that better results are possible when the men are given an opportunity to earn a little extra money. Satisfactory results, however, have been secured without this incentive in the preparation of crushed stone and road building materials at the penitentiaries and our experience indicates that this method of utilizing convict labor is preferable to construction camps.

Last year Illinois parolled a very large number of convicts for work in munition factories. Thus far the parolled men have made good. Practically all of the remaining able-bodied prisoners were used either in the preparation of road building materials or engaged on other industrial work.

Louisiana Finds Work of Convicts Satisfactory; Cost of Construction Less Than With Free Labor.

By **DUNCAN BUIE**, State Highway Engineer.

THE State highway department of Louisiana utilized convict forces for road construction at the very time the department was created by law; that is, in February, 1911, and whenever available thereafter employed this class of labor until the year 1914. After this period the Board of Control of the State Penitentiary had just sufficient men available as were necessary to work its plantation and other industries; therefore, say from the year 1914 to June 19, 1918, no convicts were used by the highway department in its road construction, because this class of labor could not be obtained.

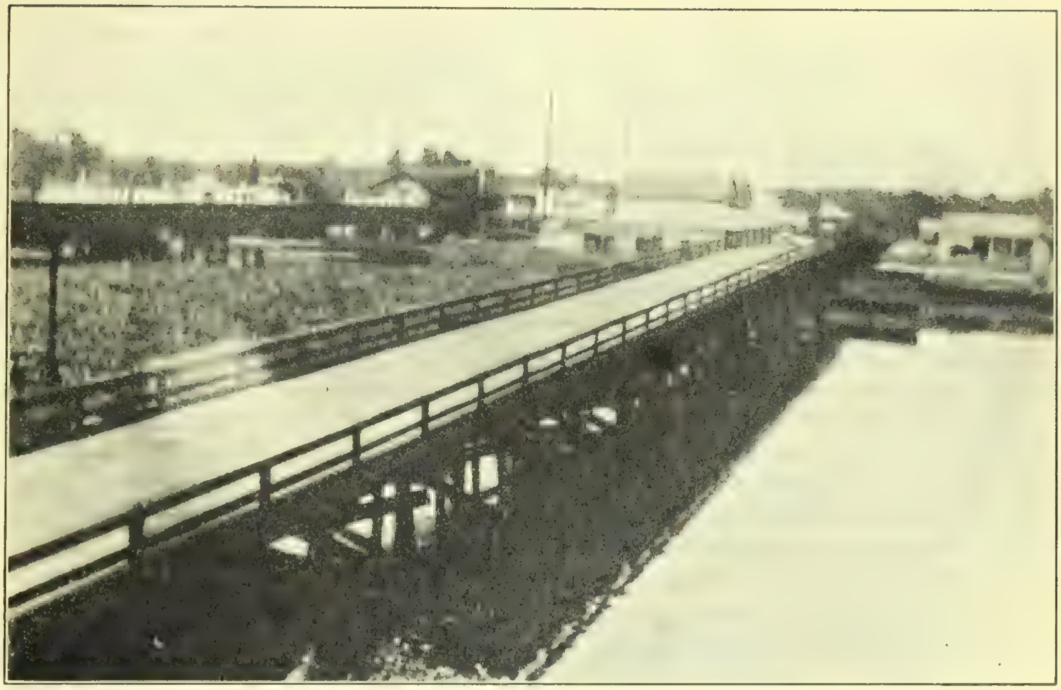
However, about July 1, 1918, the department was fortunate enough to secure from the Board of Control of the State Penitentiary, 100 convicts, at a cost of $2.50 per day, to wit: "For all men in camp and on work, except such as are in hospital and performing no work, the Board of Control of the State Penitentiary to feed and up-keep these men, including medicines, doctors, etc."

When one takes into consideration the high cost and scarcity of labor prevailing at that time, the convicts, at the cost of $2.50 per day were very cheap labor, and in fact, by their employment, materially reduced the cost of construction work on the road where they were being used, and on which, prior to their availability, free labor, such as could be secured, was used. Unfortunately the highway department had to return these convicts to the State Penitentiary by October 1 of last year, as they were needed for harvesting crops raised on the State Penitentiary farms.

CONVICTS BUILT 155 MILES OF ROAD.

Approximately 155 miles of roads were constructed with convict labor in the State of Louisiana between the period from April 20, 1908 (prior to the organization of the highway department), to April 20, 1914. This construction was divided over eight parishes (counties), and the total cost of all these roads amounted to $152,914.98. Of the 155 miles constructed 3 miles were sand-clay roads, 5 miles sand-clay gravel, and the balance ordinary earth—that is, the soil was of such a character that it was not necessary to add any sand or clay. The amount thus expended also covered the construction-of 1.1 miles of drainage canal, the canal costing approximately $3,000. The roads mentioned cost approximately $884.90 per mile for earth roads and $3,196.58 per mile for gravel roads.

At the present time the highway department would hardly venture to say just what it would cost to construct a metal-surfaced road with the use of convict labor, due to the fact that the hard surfacing material available in this State for road building purposes consists mainly of gravel and what is known as "commercial clam shells," and the price of this material is constantly increasing. However, just as a comparison between the cost of construction with free labor and with convict labor, that on



DES ALLEMANDS SWING BRIDGE AND APPROACH. THIS IS PART OF THE ROAD UPON WHICH LOUISIANA CONVICTS WORKED.

a section of road where the highway department last used convicts and where a metal surfacing of clam shells was applied the same material, prior to the use of convict labor was costing the department and parish in the neighborhood of $4 per cubic yard in place, the same work was done for $2.60 per cubic yard.

One of the principal factors in the reduction of the cost of the above construction was that the convict labor was on hand at all times, and when we were using free labor teams and work were tied up, due to the fact that the free labor did not always return to the job.

WORK BENEFICIAL TO CONVICTS.

The work in the open air adds to and improves the physical and mental condition of the convict. Being constantly on the job, in time he becomes an expert in his line, whether it be wheeler work, handling a shovel, or working a drag. Through experience he knows just how to go about it, and this also is a time saver and reduces the cost of construction.

The convicts on our road work were well housed in substantial wooden structures. Of course, they were under guard, sometimes under what is termed a "trusty," a convict who, through meritorious conduct, has earned the confidence of the penitentiary authorities. He is in reality a sort of "subforeman" or "straw boss," and acts in the double capacity of guardian and overseer.

The men were all well fed, with good, substantial food, including beef, poultry, beans, rice, potatoes, corn, corn bread, coffee, and on Sundays and holidays a few extras in the way of fruit, etc. They were not worked Sundays and holidays, but on such days did pretty much as they pleased, except, of course, they had no liberty.

Experience Gained on Rhode Island Roads Makes Ex-convicts Available for Work after Release.

By I. W. PATTERSON, *Chief Engineer, Board of Public Roads.*

THE first instance of the use of convict labor upon the public roads of Rhode Island was in 1917. Previous to that time there was no legislation providing for such use of convicts, our present convict-labor law having been passed by the general assembly early in 1917. This law provides for the employment of convicts upon State roads in accordance with a formal agreement between the State penal and charitable commission and the State board of public roads. The law further provides that the guarding and maintenance of the convicts shall be taken care of by the penal and charitable commission and that the direction of the work of the convicts be undertaken by the State highway department.

Two convict camps of 30 working men each were established in 1917. The work undertaken from both camps was the construction of bituminous macadam pavements. All of the work except the quarrying and crushing of stone was done by the convicts. It was deemed advisable to employ free labor for the quarrying and crushing of stone, inasmuch as it appeared impossible to select from the convicts men who had had experience in this branch of the work. The handling of explosives by inexperienced convicts did not appear to us feasible.

FIRST CAMP HOUSED IN TENTS.

At the first camp established, which was termed camp No. 1, the convicts were housed in a large tent. A small wooden cookhouse, a small wooden storehouse, and a dining hall consisting merely of an open-sided wooden building completed the camp structures. At camp No. 2 the men were housed in a portable wooden building.

An allowance of $1.50 per workingman day for the services of the convicts was the rate first agreed upon between the penal and charitable commission and the State highway department. When the work to be done by the convicts from both camps was approximately half finished, the penal and charitable commission insisted upon an allowance of $2.25 per man day, straight time, no deduction to be made for days when the weather permitted no work to be done. In order that the work undertaken might be carried to a conclusion by convict labor this rate was allowed, although it was deemed excessive as compared with the wages prevalent for free labor at that time.

Both roads constructed by convict labor were advertised for bids early in 1917 but contracts were not awarded. An interesting comparison of costs by convict labor and by contract at the low prices bid was, therefore, possible. The actual cost of the work done by the convicts from camp No. 1 was $26,054.68. The cost at the low-price bid in the early spring would have been $23,686.72. The work done by the convicts from camp No. 2 cost $21,105.24. The cost at the low-price bid for this work would have been $25,462.81. The variation in the results secured, as far as cost is concerned, reflects very accurately the success obtained by the use of convicts from the two camps. The results secured by the employment of the convicts at camp No. 1 were never wholly satisfactory, while the results secured by the use of convicts at camp No. 2 were highly satisfactory, both as regards costs and quality of work done.

WHY FIRST RESULTS WERE UNSATISFACTORY.

In attempting to diagnose the reasons for the variation in results secured, we arrived at the conclusion that they were due to the differences in housing facilities, in food, and in the personalities of the guards. The tent in which the convicts at camp No. 1 were housed was not wholly waterproof at times of heavy, long-continued rains. Late in the season, when the weather became cool, it was impossible to heat the tent sufficiently for comfort. The wooden building in which the convicts at camp No. 2 were housed was, on the other hand, a very satisfactory shelter. There were numerous instances of food of rather poor quality having been served the convicts at camp No. 1. The effect upon the efficiency of the gang for several days after an unsuitable meal, was very noticeable. There were pronounced differences in the manner in which the various guards dealt with the convicts, although all were prison guards with more or less experience in the handling of convicts. Our investigation of the very noticeable variation in the results secured by the employment of the convicts from the two camps convinced us that a difference in *esprit de corps* of the two gangs, occasioned very largely by the conditions mentioned, was responsible.

Our attempts to remedy conditions at camp No. 1 met with some success, but the efficiency never reached that secured at camp No. 2.

Attempted escapes at camp No. 1 were rather frequent, but attempts to escape from camp No. 2 were practically unknown.

Figures submitted to this department by the penal and charitable commission show that the average cost of maintaining the convicts at the two camps was $6.65 per man per week. The cost of maintaining prisoners at the prison was stated to be $4.20 per week, which shows an excess cost of $2.45 per man per week for the maintenance of convicts at the camps.

OBSERVATION PROVES SUCCESS.

Our observation of the use of convicts for road work leads us to believe that convict labor is a success, and is a very practicable and humane method of employing the able-bodied inmates of our penal institutions. We believe that the best results are to be secured by the use of convicts of middle age. We do not feel that the employment of convicts under 30 years of age is advisable because of the fact that the younger convicts are less apt to be reconciled to their fate, and are therefore more apt to attempt to escape and less apt to evidence interest in their work.

It appears to us highly desirable that some incentive for faithful work be offered convicts employed upon types of construction where careful workmanship is necessary in order to secure good results. We feel that a small money incentive to the convicts, a reduction of sentence for good behavior, and better food than as a rule prevails at prisons are feasible incentives.

The efficiency of our convict gangs was impaired more or less by frequent changes in personnel. Care was not taken to send to our camps convicts whose terms did not expire until after the completion of the work. We feel that it is preferable to select convicts whose terms are relatively short, but that it is an advantage to select convicts whose terms are of sufficient duration to make unnecessary frequent changes in personnel of gangs.

EX-CONVICTS EMPLOYED BY CONTRACTORS.

The honor system, strictly, was not employed at our convict camps. Guards were always in attendance over the convicts both at the camp and at the site of the work. The guards were armed with revolvers which, however, were not in evidence. At the site of the work the guards served as foremen under a superintendent employed by the State highway department. The fact that the guards were not at all familiar with road work at the beginning of course handicapped the work more or less.

The preparation and cooking of food was taken care of by convicts, who also did all the routine work in connection with the maintenance of the camp. No allowance to the penal and charitable commission was made for the convicts employed at the camp.

We are gratified to note that a number of the convicts employed upon road work in 1917 and whose terms have expired since have been employed by contractors or by this department upon road work. We have no data available to show the exact number of the convicts who since their release have taken up road work as a means of livelihood, but we know that a considerable number have done so. Several of the former convicts now employed upon road work have expressed themselves as very appreciative of the experience obtained at the camps, which has enabled them to qualify as experienced laborers.

The use of convicts was not attempted during 1918 because of the demand for practically all of the able-bodied convicts in connection with extensive farm work at the prison. But now we look for further use of convicts for the construction and maintenance of State roads in Rhode Island.

New Jersey Maintains Three Convict Road Camps; Plans To Expand System That Has Shown Value.

By **W. G. THOMPSON**, State Highway Engineer.

CONVICT labor was first used on the highways of New Jersey during the autumn of 1912, when about 15 men were taken from the State penitentiary and used on the grading of the White Horse road in Mercer County. They were transported to and from the institution each day in charge of two guards, representing the prison department, and the foreman of the State highway department, who directed their activities from a construction point of view. As the season was short, but little could be learned of the efficiency of this labor before winter weather conditions caused the stopping of work for that season.

During the summer of 1913 State road camp No. 1 was established at Andover in Sussex County. Proper camp buildings were erected by the State highway department on property owned by the county, road building equipment of various kinds was purchased by the State highway department, and operations commenced which involved principally grading, such as reducing the then existing grades of highways within the county; widening, the elimination and straightening of sharp curves, installation of drainage facilities, etc.

PRISON IN CHARGE OF WELFARE.

The direction of the construction work by these men was under the supervision of foremen and the engineers of the State highway department, while guarding, feeding, and general welfare was directly under representatives of the prison department. Sufficient guards were maintained to keep a proper watch over the gangs, several of which might be quite widely separated from each other, and considerable liberty allowed the men—that is, they did not wear a ball and chain nor was there any evidence of arms carried by the guards.

Considerable work was done though under adverse conditions, due to lack of entire cooperation between the prison department and the highway department. This was due to the defeat in the legislature of 1913 of several bills intended to enable a closer cooperation and more favorable working conditions as between the two departments. The experience gained in 1913 proved conclusively that this class of work could be done by prison labor only under the principles of the honor system. A force of about 42 men was maintained at the pioneer camp during the construction season of 1914 under five guards from the prison department. During this period but one man escaped; he was recaptured within two days and returned to the institution.

SECOND CAMP ESTABLISHED.

A second convict labor camp was established near Princeton in the autumn of 1913 at which camp the highway department undertook the housing and feeding of the labor, which was kept at the camp throughout the winter instead of being returned to the institution when the construction season closed.

The camps are frame buildings, well constructed, allowing plenty of light and air. The barracks are supplied with flush toilets, shower baths, and iron beds, all on one level, there being no double tiers of

CONVICTS EXCAVATING FOR STORM SEWER ON THE LAYTON-DINGMANS FERRY ROAD, NEW JERSEY.

berths. Mess halls are supplied with all conveniences; and cooking is done by convicts on hotel ranges. Owing to interdepartmental difficulties, the subsistence of the men was eventually taken over by the prison authorities and is still in their charge. Present laws governing the use of inmate labor on highways leave much to be desired, but with the evergrowing need for more and better roads, it is believed the enactment of more favorable legislation will come at an early date.

Notwithstanding the difficulties under which work was done, there was performed during the construction season of 1915, $41,360.31 worth of work at a total cost of $38,840.57, value of the work done being based on the then current prices for the various items. The work performed included earth and rock excavation, construction of macadam pavement, operation of stone crusher, and quarry; construction of reinforced concrete culverts, etc.

RATE INCREASES WITH HIGHER COST.

During the experimental period the State Highway Department fed and housed the men, paid the guards, and paid the prison authorities 50 cents per day per man. Later the prison authorities took over the feeding of the men and paid the guards, the highway department then paying the prison $1.25 per man per day. Of this the man received nothing as an incentive to work. Owing to increasing cost of maintenance, the rate paid the prison was increased during 1916 to $1.45 per man per day, and to $1.55 in 1917.

During the winter of 1917-18 a new agreement was effected between the State Highway Commission and the prison authorities, whereby the prison is paid $2 per day for each satisfactory man day's work; of this amount the man is to receive 50 cents which will be credited to him, or turned over to his family. They work 50 hours per week and have Saturday afternoons for recreation.

Any man whose work for a given period of time is unsatisfactory to the superintendent of the highway department is returned to the prison and is not again employed upon the work. Arrangements are now being made by the prison authorities for the mental and physical examination of each inmate of the institution with a view to establishing his fitness for employment on the roads, and in other capacities. As will readily be seen, this system, when effective, will weed out the misfits and provide men able to stand the rigors of highway work.

GOOD WORK ON ROAD TO CANTONMENT.

Until the spring of 1918 there were three camps in operation; one in Cumberland County, southern New Jersey, and two in Sussex County, northern New Jersey. These were all engaged on the construction and improvement of county roads, for which the counties involved furnished the right of way, and certain of the materials. These works were all completed during August, 1918. After that these men were assigned to be employed exclusively on construction of the State highway system.

STORM WATER DRAIN 1,400 FEET LONG TO CARRY CREEK UNDER LAYTON-DINGMANS FERRY ROAD, NEW JERSEY.

During the autumn of 1917 there was undertaken, with young men from the State reformatory, the construction of 4 miles of penetration macadam road leading to Camp Dix, a large cantonment at Wrightstown, N. J. This involved approximately 15,000 yards of grading, the laying of foundation, and surfacing of a broken stone pavement, and its binding with tar. A camp holding 50 men was established near the work, to and from which the men were transported each day in motor trucks. The State highway department paid the reformatory authorities $1.75 per man per day, of which each man received 50 cents when his work was satisfactory. The work performed by these men was so unusual in quality and quantity as to cause much comment especially when compared with free labor employed in the cantonment construction near by, and paid from $3.50 to $4.50 per day. On the work the guards employed by the reformatory acted as foremen, and were paid by the highway department. The reformatory fed and clothed the men out of the $1.75 per day.

CAMP BUILDINGS IN SECTIONS.

Under the present program there are established three camps, each capable of housing 110 men. The highway department furnishes all housing facilities, including heat, water and light, the prison department furnishing guards and feeding the men, while supervision for construction work and the determination as to satisfactory work was entirely under the highway department, which also furnishes working equipment, consisting of steam shovels, grading machinery, motor trucks, wagons, concrete mixers, and small tools.

On all of this work the superintendent's status is exactly that of a contractor. Plans, specifications, and estimates are prepared as if a contract were to be let, and the superintendent must keep within the estimated cost. No extras are allowed except by written order. In each of these projects the work calls for approximately 4 miles of concrete pavement, with culverts, bridges, guard rail, etc., all of which will be performed by this labor. All mechanical equipment is operated by free labor, though in some instances teams are driven and pumps operated by inmate labor.

All camp buildings are built in sections, so they may be readily set up and removed. The main building contains sleeping quarters, kitchen, and mess hall for 110 men, besides quarters for guards and officers and an office. There is provided a tool and material house, from which is checked out all tools and materials needed, and to which the tools must be returned. This includes gasoline, oils, and greases. Sheds are provided for trucks and other equipment, while a machine and blacksmith shop provides repairs for equipment.

SYSTEM WILL BE EXPANDED.

All purchases of materials, supplies, and equipment for these works are made through a Purchasing agent at the central office, the several superintendents making out requisitions therefor as needed. The above outlines briefly methods of administration and operation as applied to inmate labor on State work.

The system is but in its infancy and will be expanded as rapidly as numbers of men available will permit, and existing laws are amended or modified to permit greater elasticity in the disposition of the men in the field, and a closer co-operation between the reformatory institutions and the Highway Department.

Of the value of the labor there is no doubt. A decision after comparison between the labor of these men at $2 per day and the general run of free common labor at from $3.50 to $4 per day is decidedly in favor of the inmate labor. From a sociological point of view, the benefits are inestimable, as the men are employed regularly in the open air amid healthful surroundings, as opposed to the old system of hiring them to contractors within the institutions. Considering the numbers of men employed on the highways, very few have attempted or effected clean escapes.

Facilities are provided for athletics, in which the men are permitted to indulge on Saturday afternoons and Sundays. These help to maintain the general morale, and give the men something to look forward to.

The State highway department of New Jersey will be glad to give to other States, and to all interested the benefit of its experience and observations in connection with this work.

Good Results With Convict Labor In Wyoming.

By Z. E. SEVISON, State Highway Engineer.

PROVISION for the use of convicts on the roads of Wyoming was first made by the legislature in 1911 by the passage of an act putting the matter in the hands of the State board of charities and reform and appropriating funds for the purchase of machinery and equipment. Under this law the plan has been followed that convicts might be used on road construction wherever a county agreed to bear all the cost of maintaining them.

During the years 1911–1917, inclusive, a varying number of convict gangs were employed on the roads in the different counties. The size of each gang varied from 10 to 20 men. Practically ali of the work was apparently done as is usual with county road work, without survey or plans and with no record of the cost of the work.

During the year 1917 a convict gang of 16 men continued work on the Cokeville-Star Valley road which had been in progress for two years previously, but working according to the surveys and plans of the State highway department. The entire cost of the work in 1917 was paid by Lincoln County. This project having been approved as Wyoming Federal-aid project No. 21 previous to the 1918 working season, a gang of 18 convicts was placed on the work and was the only convict built road work under way in Wyoming last year. Other convicts which ordinarily would have been available for road work were placed on the farms and ranches on account of the serious shortage of such labor.

This project is located entirely in a canyon, involving a considerable amount of rock work, the percentage of team work being relatively small. This class of work is particularly adaptable to convict labor and is much more advantageously completed than that where it is customary to use principally teams and machinery. It has been the observation of the writer that the work done per convict per day on this project is equal to that of common labor such as was available at the time.

The gang was in charge of a superintendent employed by the State board of charities and reform; a foreman was also employed. Camp and road building equipment were furnished by the State. The superintendent was paid 40 cents per meal for boarding the men. No guards whatever were provided and it was customary to send the men alone to the nearest railroad point, a distance of 36 miles for supplies and to distant ranches for hay and feed. Guns and ammunition were furnished for hunting, also fishing tackle for trout fishing and a very considerable proportion of the fresh meat used at the camp was obtained in this way. The State board of charities and reform allowed each convict $5 per month for tobacco, etc.

During the past two years only two men have attempted to escape and in other years such attempts have been very infrequent.

Without question the use of convicts on road work in Wyoming has been a success, particularly on roads in mountainous country. It is expected that the use of convicts will be continued on road construction and it is hoped that conditions will be such in the other lines of work where they are employed that an additional number will be available, particularly during the duration of the war.

ROAD BUILT BY WYOMING CONVICTS.

Convict Labor on the Mountain Roads of Utah Proves a Notable Success in Heavy Construction.

By IRA R. BROWNING, State Road Engineer.

USE OF convict labor on the public roads in years past in Utah and other thinly settled western states has been given very little attention, probably because of the difficulties of transporting and guarding the prison gangs in the districts where suitable projects of road construction were required and under way.

Shortly after the organization of the State road commission of Utah, however, definite steps were taken toward utilizing convict labor on difficult and extensive sidehill cuts, rockwork, and almost impassable sandy sections of the roads in southern Utah.

The first two years during which such labor was employed resulted in such creditable road improvement as to establish definitely this type of labor for difficult rockwork, heavy cuts, and sidehill construction. One of the requirements in connection with convict labor in the mountain districts must be the compactness of organization in order to effectively guard the prisoners and prevent wholesale escapes from camp into the mountain fastnesses; and this naturally limits their work to heavy construction.

WORK ON NOTABLE PROJECTS.

Notable construction projects upon which the prison labor has been employed in Utah include the Black Ridge road; Grapevine sands and the roads leading to Hurricane and to Little Zion Canyon in Washington County; the Price-Myton Road in Carbon County; Fisher Pass section of the Lincoln Highway, Tooele County; Willow Creek section of the Castle Gate-Duchesne post-road project, Carbon County; the Courthouse Springs section of the Thompson-Moab post-road project in Grand County; and the first section of concrete road paving in Davis County.

In the summer of 1918, after disastrous floods had washed through Mount Pleasant city, Sanpete County, leaving devastation in their path, the State road commission and the State board of correction cooperated in sending a steam shovel outfit and a force of convicts to assist in clearing the streets and reestablishing drainage channels through the city. Especially in this work at Mount Pleasant the work of the convicts has elicited much favorable comment by competent observers. The labor shortage was never more keenly felt than in midsummer of last year, and the relief that came to the citizens of Mount Pleasant by the prompt establishment of an effective working force has been attested by the mayor, the city council, and many other prominent citizens.

HONOR SYSTEM A GREAT AID.

We have had gangs of prisoners and of ordinary laborers working on the same roads in Utah at various times and have been impressed with the lack of efficiency of the convict laborers at times, due to their lack of dependability for regular service on working days. For instance, a gang of 30 convicts showed an average of less than 20 regularly employed at road work during one period of observation. The inclination to stay in camp on account of slight illness or indisposition accounts in a large measure for the disparity between convict and free labor. However, it is confidently believed that a solution has been found for this problem; the "honor" system among the prisoners that will abide by the rules granting more liberty has placed them practically on a par with the average free laborer so far as effective work is concerned.

In the course of extending this system among the prisoners Warden George A. Storrs of the Utah State prison was subjected to a somewhat annoying criticism when he sent a trusty convict, armed, to overtake an escaped prisoner. The trusty continued on the chase into adjoining States, reporting at intervals his nonsuccess. In accordance with the faith of the warden, the trusty convict returned, much to the surprise and chagrin of his erstwhile critics.

It is believed that a foundation is being laid for utilizing prison labor to a greater extent and to greater advantage than ever before, especially in connection with the improved types of highway construction.

Convict Work on Roads of Idaho Could Be Made Profitable to State and Beneficial to the Men.

By H. C. ALLEN, State Highway Engineer.

THE EXPERIENCE of the State of Idaho with convict labor has not been very extensive, at least in the line of road building.

In the year 1916 a convict construction camp was established in the Salmon River Canyon in Idaho County near Whitebird and a short stretch of heavy construction begun under the supervision of the State highway department. The results obtained on this work were rather disappointing because of the heavy overhead expense connected with it. This was due very largely to the remoteness of the work and the consequent high transportation costs of the men from and to the penitentiary and also to the fact that not enough convicts were available for that kind of a camp to keep down the overhead expenses to a minimum. At this camp the men were housed in tents and were fed and treated much the same as free laborers in a contractor's camp.

In 1917 some convicts were used on a piece of rocky, canyon road in Bonneville County. This work was done under the supervision of the prison board and not by the highway department. At this camp, as at the Salmon River camp, the men were out on their honor, no armed guards being used, and, I believe, none escaped. The work was satisfactory at this camp and the results compared very favorably with contract work.

Early in the year 1918 arrangements were made between the prison board and the commissioners of Ada County for the joint expenditure of a limited amount of money for grading a short stretch of highway (on designated State highway location) adjacent to the penitentiary. The old road at this place was very narrow, rough, and rocky. The highway department furnished the engineering and a truck for hauling the prisoners from and to the penitentiary. The labor performed by the convicts compared very favorably with free labor, but because of the divided responsibility in the organization the results obtained were not the most satisfactory, though in general it is felt by the authorities that value was received for the money expended. This work would not have been done at this time had the convicts not been available for the work.

The behavior of the men was very good and they appeared to be much better satisfied than when they were behind the walls. The foreman and the truck driver were the only authorized guards on this work and they were unarmed. Only one escape was made from a crew of 15 prisoners in a period of about eight weeks.

Late last fall the highway department repaired some paved roads within 10 miles of the penitentiary, and as it was almost impossible to secure free labor it was decided to use a crew of convicts on this work. Had the convicts not been available the repairs would have had to wait until some future time. The men were transported back and forth from the penitentiary in a truck. Their lunch was carried with them. The work they performed on this road is very satisfactory and, as stated above, had they not been available this pavement would have been in almost impassible condition for another year at least.

CONVICTS AT WORK ON THE MARYSVALE-SEVIER ROAD, UTAH, SHOWING THE METHOD OF BUILDING FOUNDATIONS IN THE SWAMP AT BLACK ROCK. NOTE THE LARGE STONES BLASTED FROM THE OBSIDIAN CLIFF WHICH WERE LAID IN THE SWAMP IN WHICH SMALLER ROCK AND GRAVEL WERE PILED AFTERWARD.

At the same time the prison board had a gang of about 15 or 20 convicts in camp on a county road about 50 miles from the penitentiary in Canyon County. Their work consisted in reducing a steep, rocky grade.

The penitentiary has for the last few years maintained a large ranch which is farmed by honor men from the prison. In addition to this the penitentiary rented another large farm near Boise for the purpose of increasing the crop production of the country and on which prisoners are worked.

The subsistence of the men on road work, whether obtained at the penitentiary or in camp, is charged to the work. The men are paid a small sum for their work, which is credited to them on the prison books, and this tends to promote some interest in their work.

There is little doubt that with proper organization and when the work is within reasonable distance from the penitentiary the working of convicts could be made profitable to the State as well as beneficial to the men.

Nebraska Experiment Produces Good Results.

By **GEORGE E. JOHNSON**, State Engineer.

CONVICT labor has been found profitable in the construction of roads in the State of Nebraska. In 1915 one and one-half miles of pavement was put down on Holdrege Street and Warren Avenue in Lincoln, Nebr.

The summer prior to the meeting of the 1915 session of the legislature a movement was started in the city of University Place, which is about 1½ miles from the city limits of Lincoln, to pave the road between those two places. University Place and the county controlled only 50 per cent of the frontage on the proposed pavement. The State, by virtue of the State Agricultural College, controlled the other 50 per cent.

A bill was introduced at Gov. Morehead's request which called for the necessary appropriation to pay for one-half the cost of the abutting pavement. The bill empowered the governor to construct the State's share by the use of convict labor. The contract for the city and county's share of the work was let in July, and by agreement the contractor took the east half of the district and the State the west half. Contracts for necessary material were entered into by the governor, and the State engineer's office was instructed to take charge of the work.

STARTED WITH SEVEN MEN.

The road was to be 32 feet from curb to curb; 6 by 20 inch concrete curbs were specified, as well as a 5-inch concrete base with a re-pressed brick surface filled with asphalt placed on a sand cushion.

The work was started on August 27 with seven convicts, two of whom were carpenters, and the others were used to unload cement and store it in a near-by barn which was prepared for that purpose. Four cars of cement were stored in this storehouse and were held for emergency work. The following week 30 more men were received and the construction work began.

The wooden forms used for the curb were made by the convicts. The concrete mixed at a central plant and hauled in the regular grader dump wagon to the work proved satisfactory and economical.

The majority chosen for the work were short-term men, with the exception of two who were under life sentence. Selection was based on the individual's ability and willingness to work, reliability, and trustworthiness. Upon leaving the penitentiary they gave their word of honor not to attempt to escape. There was no night guard, and the day guard was there only to see that all rules were observed. The men were housed in the stock-judging pavilion of the State university farm, and meals were prepared by one of their own number.

CONVICTS WILLING AND FAITHFUL.

During the 90 days there was but one man who broke parole, a colored lad who had four months to serve. One other man was sent back because he attempted to create a spirit of dissatisfaction among others.

The men were willing and faithful, and felt that they were just becoming efficient in all divisions of the work when it was finished. Each man took a secret delight and personal satisfaction in the accomplishment of a day's work. On Sundays they were frequently found examining and comparing the adjoining contractor's work with their own. Their work was entirely satisfactory. It may be noted that only three men out of the number employed had ever before worked on any kind of construction work.

The majority of these convicts have been released and are now employed in useful work. Outsiders and certain public officials took as much personal interest in the work as the men themselves.

As a result of the convict labor Nebraska has 1½ miles of excellent pavement, perhaps the best in the State. Financially the work was a complete success. Using the adjoining work as a basis of estimating the probable cost of the pavement laid by the convicts, the net saving to the State was $5,624.28.

MICHIGAN ENCOURAGES ROADSIDE TREE PLANTING.

Tree planting along State trunk highways and other roads built under the State reward system has been intrusted by a recent act of the Michigan Legislature to the State Highway Commissioner and the State Board of Agriculture. The law makes it their duty to set out ornamental, nut-bearing or or other food-producing trees, suitable for shade trees, and the Michigan Agriculture College and Public Domain Commission are authorized to distribute stock for the same purpose at nominal cost to local officials and private individuals who will set it out at intervals of 20 to 40 feet along the roads. Injuring trees along the highways or affixing notices of any kind to them is made a misdemeanor punishable by a fine of $1 to $25 or imprisonment for not more than 30 days.

DOMINION GOVERNMENT AID FOR PROVINCIAL HIGHWAYS.

United States Consul General John G. Foster, Ottawa, Canada, has made the following report to the State Department:

The Dominion Government has introduced a resolution in the House of Commons providing for the payment within the next five years of $20,000,000 to the various Provinces for the encouragement of the construction of good roads. According to the terms of the resolution each Province will receive $80,000 every year plus a further payment based upon population as determined by the latest federal census of each Province. The payments will be subject to the following conditions:

(*a*) Any highway for which aid is granted shall be constructed or improved, as the case may be, in accordance with the terms of an agreement to be made by the Minister with the Government of the Province, which agreement shall contain such provisions as to cost, description, specifications or otherwise as the Governor in Council may approve.

(*b*) The aid to be given in any case shall be 40 per cent of the amount, which in the opinion of the Minister, is the actual, necessary and reasonable cost of the construction or improvement of such highway as the case may be.

Canadian roads have been divided by the Provinces into three classes: (1) Main highways, on which the greatest amount of traffic will take place; (2) market roads, carrying not so much traffic but leading to the market centers; and (3) roads leading to market roads, and first-class highways. The first class are built by the Provinces, the second by the Provinces and municipalities, and the third by the municipalities. The Dominion Government proposes that the federal money shall be advanced only on the first class of roads. The Dominion Government will have the power to appoint inspecting engineers and until the roads are constructed to the satisfaction of the Minister in charge of the good roads branch no grant can be allowed.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Applications for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

BULLETINS.

(In applying for these publications the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28.")

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction on the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
24. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A Summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Prservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. (1911.) 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magniture on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. *239. The Corrosion of Wire Fence. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts. 5c
*461. The Use of Concrete on the Farm.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads

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* Department supply exhausted.

* Department supply exhausted.

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U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 14 WASHINGTON, D. C. JUNE, 1919

ONE OF THE ROADS IN DELAWARE'S NEW HIGHWAY SYSTEM

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both Houses of Congress. Others desiring to obtain "Public Roads" can do so by sending 15 cents for a single number or $1.50 for annual subscription to the Superintendent of Documents, Government Printing Office, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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SECRETARY HOUSTON DISCUSSES FEDERAL ROAD COMMISSION BILL

SECRETARY HOUSTON, in response to a communication from a city chamber of commerce requesting his views regarding the creation of a Federal highway commission and the wisdom of taking the Federal supervision of highways from the Department of Agriculture and placing it under such a commission, has sent the following reply:

"I have your letter of May 2 in which you state that your chamber of commerce has been asked to adopt a resolution calling on the Congress of the United States to create a Federal highway commission and that you note that such resolution has been adopted by a number of commercial organizations, including the United States Chamber of Commerce. You ask for an expression of my views on the matter and particularly whether, in my opinion, it would be wise to take the Federal supervision of highways from the Department of Agriculture and place it under such a commission as that proposed.

FUNDAMENTAL CONSIDERATION.

"Before expressing my views, it might be well for me to point out certain fundamental considerations which should be borne in mind in determining any sound policy of highway administration and development: (1) The roads in each section of the country are of varying degrees of importance in the service which they render or may render to the particular locality, to the State, and to the Nation as a whole. (2) This is a big country and the traffic conditions and needs vary greatly from section to section. (3) The State highway departments, being in immediate touch with local conditions, are best able to classify the roads properly on the basis of the economic purpose which they may serve. (4) The Federal Government, under the present Bankhead Federal Aid Road Act, is cooperating in the improvement of the roads of greatest importance, the classification of which is fixed by the State highway departments; and (5) when this classification has been carefully made and by agreement between the highway departments of adjoining States, the roads of first importance generally meet at State boundaries, and, therefore, become interstate highways of nation-wide utility. The Federal Government, under the present law, is aiding the State highway departments in the classification of their roads on the basis of importance and needs, and Federal aid is rapidly being extended for their improvement, on projects submitted by the States and approved by this department.

FEDERAL COMMISSION NOT NEEDED.

"Having those points in mind, I have been unable to see the need for the creation of a separate Federal highway commission or the wisdom of substituting for the present cooperative program a plan which would commit or limit the Federal Government to the construction of two federally owned and maintained trunk lines in each State of the Union. There was a bill introduced in the Senate of the United States on February 13, 1919, embodying these suggestions. This proposed legislation provides for a Federal highway commission of five, each receiving a salary of $10,000 a year, whose duty, among other things, would be to establish, construct, and maintain a system of highways 'to comprise not less than two main trunk line roads in each State, and joining the national highway system in the adjacent States and countries.' The commission is given the power to select the trunk-line roads to be constructed after having requested the State highway departments to recommend routes. The Federal Government is to assume the maintenance of these roads. The commission is furthermore empowered to take over the work of all existing Federal agencies relating to highway transportation and 'to purchase, lease, rent, operate, and maintain such motor and other transportation facilities as it may deem necessary in performance of its duties under this act.'

OPERATION OF PRESENT LAW.

"In July, 1916, the Bankhead Road Act was passed. It provided appropriations out of the Federal Treasury, to be matched by equal sums from the States, for the construction of roads, and provided further that no State should receive any of the money appropriated unless it had a highway department with adequate powers. The law placed the administration of the act in the hands of the Secretary of Agriculture, in cooperation with the 48 State highway departments. It was enacted only a short time before we entered the European war and its operation was necessarily greatly interfered with by the disturbed conditions. There were also certain features of the law that made its smooth administration difficult. After the cessation of hostilities, with the approval of the President, I requested Congress to make a large additional appropriation to aid the States in highway construction and also to make certain amendments to the law, the necessity for which experience had demonstrated. Congress, through the Bankhead amendment to the post-office appropriation bill, provided an additional appropriation of $209,000,000 and substantially made the amendments suggested.

"Under existing legislation there is no special obstacle, so far as I can see, to the construction, in the different States of the Union, of those roads which serve the greatest economic needs. In the first place, the definition of the kind of roads that can be constructed has been greatly broadened, and in the second place, the limitation on the Federal contribution for any one road has been increased from $10,000 to $20,000 a mile.

COOPERATION WITH STATES.

"Following this legislation, the regulations governing the administration of the act and the standards for plans, specifications, and estimates have been modified and one of the most successful former State highway engineers in the country has been placed in immediate charge of the Federal aid road work. He has at his disposal a considerable staff of local and district engineer aids and no pains will be spared to provide any further Federal assistance that may be needed. The machinery provided by the Bankhead amendment includes not only the Federal Bureau of Public Roads, one of the largest and most effective organizations of its kind in the world, but also the 48 State highway departments, the two agencies working in close cooperation. It is also a part of the plan to have an advisory committee, composed of representatives of the State highway departments, selected by the American Association of State Highway Officials with due regard to geographic considerations, to work in intimate touch with the Federal Bureau, meeting with its officers at stated periods and at such other times as may be necessary. This machinery, in effect, is an expert national commission intimately in touch through its various parts with all sections of the Union, having no other purpose than that of serving the public interest. It is difficult to see what need there can be for additional machinery.

STATE OFFICIALS SELECT ROADS.

"Very properly the Bankhead Act places on the highway authorities of the several States responsibility, in large measure, for selecting the roads to be constructed. Obviously the local authorities are in a better position to judge what roads would serve the largest economic needs than any group of men sitting in Washington would be. It is the duty of the Federal Bureau, with its district engineers, to see that the provisions of the law are complied with. It is giving, and will continue to give, all possible assistance to the State authorities in all their technical problems, as well as in the planning of State systems and in the classification of roads. It has been the policy of the department from the outset, in order to prevent haphazard action, to have the State highway authorities prepare and present tentative State systems of roads. It was apparent that a rigid system, not subject to modifications as conditions might require, would be inadvisable. Each State authority has worked out a system and, in general, it is being followed in the development of projects and the construction of roads. In a number of instances systems in general terms have been adopted by State legislatures. Of course, in formulating these systems the engineers gave due regard to interstate connections; that is, to roads connecting the system of one State with that of another, and it is difficult to see why, as progress is made, the construction of through roads will not follow, as a matter of course.

OBSTACLES IN WAY OF NEW PLAN.

"It seems scarcely likely, in view of the fact that nealy $300,000,000 are now available out of the Federal Treasury, that the Congress, in the light of the financial situation, will make additional large appropriations; and it would be impossible without creating many complications to divert the existing appropriations from the purposes and plans already under way under the cooperative arrangements with the States. A considerable part of the available appropriations has already been formally tied up under agreements with State departments and contracts for large sums have been let. Additional large amounts are being pledged monthly. Every State has accepted the Federal act and many of them have by law directed its agencies to cooperate with the Secretary of Agriculture. A number of the States have large sums available for cooperation, in many instances much in excess of what is necessary to meet the requirements of the Federal act, and other States are preparing greatly to increase their appropriations. These State laws and arrangements can not easily be changed and perhaps would not be. After the original act was passed, more than a year elapsed before many of the States were able to secure legislative action which would enable them to comply with the Federal law and to begin the construction of roads. With the passage of the amendment carrying a large additional appropriation, there arose a necessity for further legislative action in some of the States. It seems to me that instead of asking for more or different legislation we should now proceed actively and vigorously with the construction of roads under existing arrangements.

NOTHING GAINED BY COMMISSION.

"I am convinced that nothing material would be gained by the proposed change. Much would be lost. As has been pointed out, many complications would be introduced. The creation of a commission would entail unnecessary additional administrative expenditures and the commission could not do anything that can not now be done more effectively by the existing cooperative machinery. There would also be a radical change of policy. I do not think that the people of the States will be willing to substitute for the present policy of developing roads on the principle of serving the largest economic purposes that policy advocated by those whose interest is in two main or trunk-line automobile roads in each State, nor do I think that they would be willing, even if it were legal or practicable, to have existing funds diverted from the present or contemplated projects, worked out with the aid of the State highway departments, solely to the construction of such roads. The largest service will be rendered, not only to farmers, but, in the long run, also to urban people, by following the principle of constructing roads of the greatest economic importance, selected after careful consideration by the State agencies having adequate knowledge and approved by the Federal department. It seems to me clear also that, as the work proceeds, we shall have roads which will be equally serviceable not only to those interested immediately in long-distance automobile travel and motor-truck transportation, but also to those interested in getting their farm produce to the market in the easiest and the most effective manner and in the transportation of the mails. I have no prejudice against any sort of road except a bad road, or against any sort of construction except wasteful and unsubstantial construction. If traffic conditions require heavy construction, then I am in favor of it; and in any case, under the law, the construction must be substantial.

GOOD RESULTS OF BANKHEAD LAW.

"The road-construction movement is growing very rapidly. The Federal aid road act has done much to promote it. It has stimulated financial aid and has caused many State legislatures to create central highway departments. Experience has brought about amendments to the law and helpful changes in administration. Comprehensive road programs have been inaugurated. They are being pushed vigorously. They will result, in a shorter time than most people imagine, not only in a network of good, substantial roads in the various States of the Union, but also in the requisite interstate highways.

WHY INTRODUCE COMPLICATIONS?

"Why at this stage introduce complications and embarrassments? Why should not the friends of the movement for roads to serve the people cooperate? It is difficult for me to see why all who are animated by high public spirit in their thinking concerning highways should not cooperate in the development of present programs and in the perfection of the existing processes and machinery, instead of attempting to overthrow them. I believe that many of those who are backing the proposed change do not know the facts and are not aware of existing conditions and possibilities."

$6,500,000 FOR DALLAS ROADS.

Dallas County, Tex., on May 24, voted by an overwhelming majority to issue road bonds to the amount of $6,500,000. The commissioners and advisory board will determine at an early date the initial expenditure to be made from this amount. The plan submitted to the people with the proposition provides for a complete belt line around the county, with 12 roads radiating out from Dallas to all sections, and in addition 6 intermediate roads connecting the radial highways. The proposal showed the location of each of these roads, its construction, location of culverts and approaches, the cost of each section and of the improvements upon it.

The system provides for 332 miles of road, and in addition feeder roads amounting to about 100 miles will be improved by the decrease in maintenance expense. Federal aid amounting to $250,000 had been allowed to Dallas County for its highway development, and a large number of motor trucks will be assigned to assist in the construction work.

This Dallas bond issue was by far the largest amount ever submitted in any county in Texas, and it is one of the largest voted anywhere in the country. The result of the vote was looked for with great interest by Texas people, and the big majority by which the proposal carried is expected to have a favorable influence in State election in November on an issue of $75,000,000 for road construction.

Many counties near to Dallas have voted bond issues for large amounts. Collin County voted $3,000,000; Hunt, $2,000,000; Denton, $1,650,000; Titus, $1,500,000; Kaufman, $1,450,000; Rockwell, $800,000; and Ellis, $250,000. Tarrant County will soon vote on a proposed issue of $3,500,000, and there are several other counties which have pending issues.

COUNTY TO SPEND $2,000,000.

Washington County, Miss., now has available over $2,000,000 for highway improvement. There is an unexpended balance of about $800,000 from a bond issue of $950,000 voted three years age, while it was recently decided by a large majority at a special election to issue an additional amount of $1,250,000 for road building.

DELAWARE'S FEDERAL AID WORK

By A. R. LOSH, Acting District Engineer, Bureau of Public Roads.

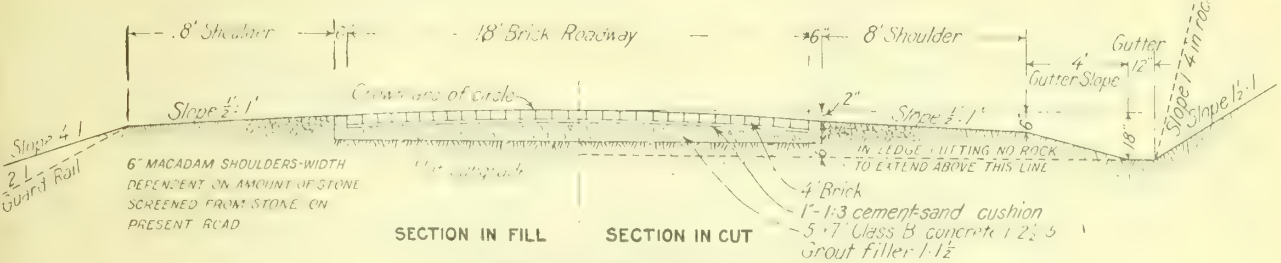
REDUCING AN 11 PER CENT GRADE TO 5 PER CENT ON DELAWARE PROJECT NO. 1A.

THE policy followed by the State highway department of Delaware in the selection of Federal aid projects has been to place the Federal funds on the trunk highways of the State system. As only a small portion of the State highway system has been constructed, it has been possible to select as Federal aid projects the most important roads of the State. A further policy of the department has been to place as large a mileage as practicable on the Federal aid program so as to insure in a measure the future maintenance of the roads. As a result of this policy, and due to the fact that the Delaware apportionment is comparatively small, the Federal fund allotted to projects has been but a small percentage of their total cost.

The Federal aid allotment to the State for the first three years of the original Federal aid, amounting to $48,965.10, was assigned to projects 1A and 2, and is but 4.1 per cent of their estimated cost. The Federal aid act as amended provides $130,349.55 for the first three fiscal years ending June 30, 1919. Projects have been submitted in excess of this sum as shown in the following table.

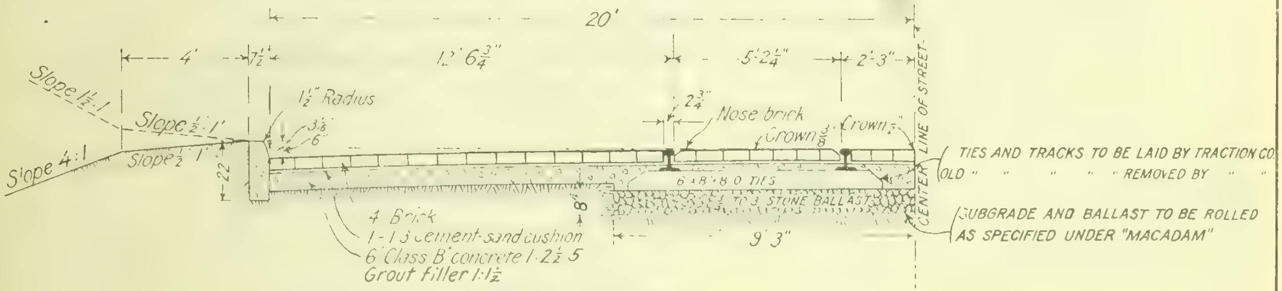
DELAWARE FEDERAL AID PROJECTS.

Project.		Length in miles.	Roadway.		Estimated total cost.	Federal aid allotted.	
No.	Road.		Type.	Width.		Amount.	Per cent total cost.
				Feet.			
1A	Philadelphia Pike	5.72	Brick	19	$639,349.59	$28,550.00	4.46
1B	do	.492	do	40	83,116.72	4,500.00	5.41
2	Laurel-Bridgeville	11.6	Plain cement concrete	16	537,827.40	20,415.10	3.79
3	Greenwood-Farmington	4	do	16	137,601.73	36,000.00	26.16
4	Delmar-Laurel	4.39	do	16	177,936.00	40,000.00	22.47
5	Farmington-Harrington	5.96	do	16	210,143.11	54,000.00	25.69
	Total				1,785,974.55	183,465.10	10.272



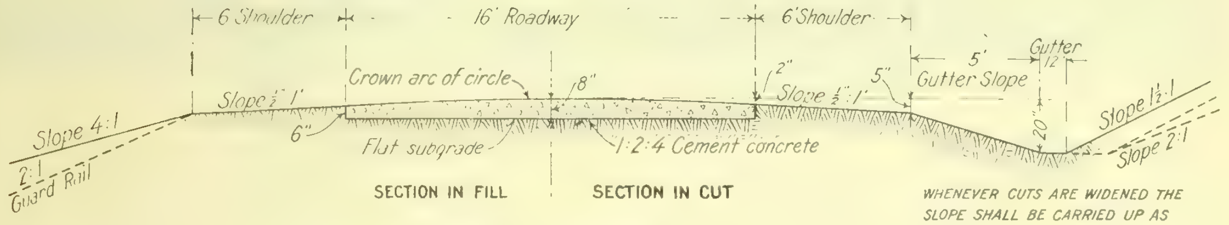
TYPICAL SECTION

DELAWARE FEDERAL AID PROJECT NO. 1A



TYPICAL SECTION

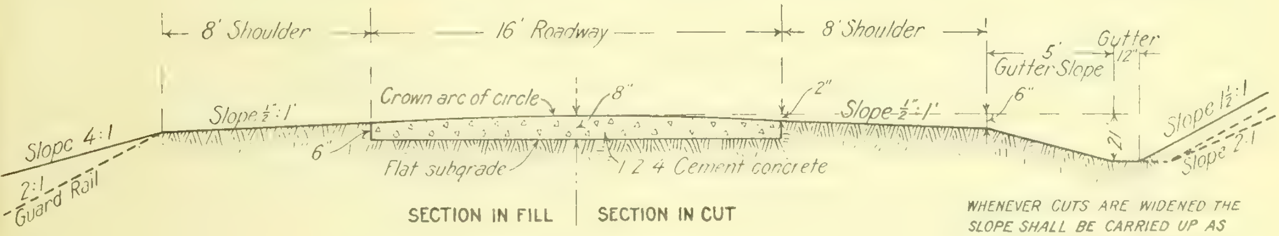
DELAWARE FEDERAL AID PROJECT NO. 1B



WHENEVER CUTS ARE WIDENED THE SLOPE SHALL BE CARRIED UP AS SHOWN AND THE WIDTH SHALL NOT EXCEED 3 FEET

TYPICAL SECTION

DELAWARE FEDERAL AID PROJECTS NOS. 2-4



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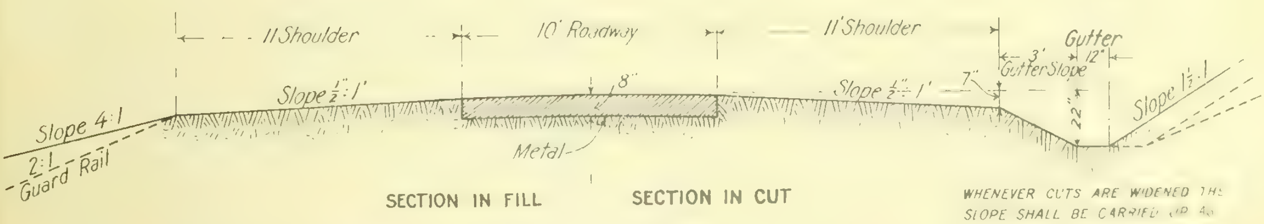
TYPICAL SECTION

DELAWARE FEDERAL AID PROJECTS NOS. 3-5



WHENEVER CUTS ARE WIDENED THE SLOPE SHALL BE CARRIED UP AS SHOWN AND THE WIDTH SHALL NOT EXCEED 3 FEET

TYPICAL SECTION

DELAWARE STATE AID PROJECTS

LOWERING TELEPHONE WIRE CONDUITS ON DELAWARE FEDERAL AID PROJECT NO. 1. NOTE THE TEMPORARY CABLE ON THE RIGHT.

The State highway department is concentrating its efforts at the present time on building the trunk highways of the State system. In anticipation of future heavy motor-truck traffic, the building program provides for substantial improved types and only high-grade work. Generally these roads pass through agricultural sections and for that reason it is possible to make the design and location on broad engineering principles and without greatly disturbing existing permanent improvements.

RIGHTS-OF-WAY.

On all trunk highways the minimum right-of-way taken is 60 feet. The Philadelphia Pike, Federal aid projects Nos. 1A and 1B, has a right-of-way of 80 feet. This width was taken in anticipation of future suburban development along the project. As it serves the industrial section between Wilmington and Philadelphia, a large portion of property adjacent to this highway is being developed for residential purposes. The last State legislature passed a law enabling the State highway department to construct roads through incorporated towns. On roads through towns and adjacent to cities rights-of-way of 80 feet will be established in order to insure sufficient width for traffic ways and allow for future planting and parking as may be found desirable.

STANDARD ROAD SECTIONS.

The road sections typical of the Delaware project are shown in figure 1. It will be noted that the sections are quite wide beyond the edges of the improved roadway. The section for project 1A provides in addition to the 19 feet of brick and concrete, macadam shoulders from 4 to 8 feet in width. On project 1B the middle of the roadway is occupied by two electric railway tracks and to accommodate traffic the roadway has been widened to 40 feet between curbs. Projects 2 and 4 have earth shoulders 6 feet wide, while projects 3 and 5 have shoulders 8 feet wide. The reason for this difference is that on projects 2 and 4 the soil is quite sandy and the shoulders of this material would not be suitable for traffic, while on the other two projects the soil is of such a nature as to make it practical to maintain an earth roadway on each side of the concrete.

The special section shown with an improved roadway of only 10 feet in width is to be used where the present traffic is light but where an improved road is needed to develop the country served. It is proposed to build the improved roadway for one line of traffic, using the shoulders, which are to be 11 feet wide, for passing, and, if desired, for horse-drawn vehicles. If traffic increase warrants a wider roadway the same can be provided readily by the addi-

DERRICK CAR, CLAM-SHELL BUCKET, AND MOVABLE BINS ON WIDE GAUGE TRACK, DELAWARE FEDERAL AID PROJECT NO. 4.

tion of concrete slabs to one or both sides of the 10-foot roadway. Generally the improved width of 10 feet will be of bituminous macadam on a slag base. This section is especially adaptable at this time to the east-and-west State highways and to State aid highways on which the counties cooperate in the cost of the construction.

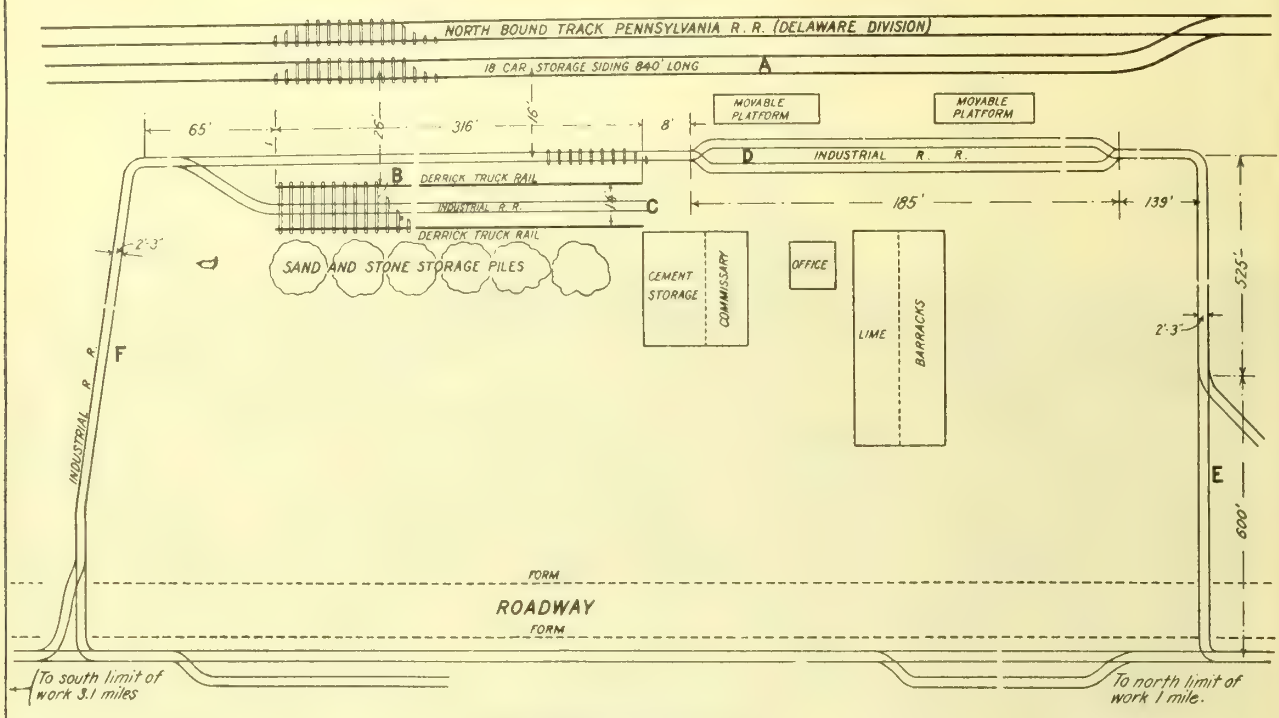
ALIGNMENT.

Alignment receives very careful study of all roads improved by the State. Little attention is given to existing roads, which were laid out generally along property lines. The practice of the State highway department is to build on long tangents and easy curves, going to considerable expense where necessary to secure such a line. One of the State highways has a tangent 14 miles long; other tangents of several miles in length are not infrequent. Curves of more than 2 degrees are exceptions to the general practice of the State. The maximum curvature on the present established State highway is 6 degrees. As a result of this practice a great many relocations are necessary. Generally it has been found that the saving in the cost of construction due to the saving in distance on the relocated line is sufficient to pay for the new right of way and property damages. This is not, however, considered as a limiting factor in deciding upon locations. On Federal aid project No. 2 there are several relocations that have been quite expensive to make and with very little saving in construction cost. On one of these where the saving in length is small the relocation has required moving a house, several farm buildings, and the building of a 20-foot span concrete arch with heavy earth embankments. This was done in order to avoid two dangerous curves and the placing of the roadway over a mill pond dam, as was the case with the old road.

The maximum gradient for Delaware State highways is 6 per cent. This maximum occurred on project No. 1A where, before improvement, the grade was 11 per cent. This particular piece of work required the removal of a large amount of rock.

DRAINAGE.

Road drainage often presents difficult problems. On project No. 1 there is ample fall, and means for surface drainage are provided readily, except occasionally where special outlets are necessary. Underdrainage, in this case, is much more difficult, because of the nature of the soil. Special tile drains are provided on long grades where there is danger that ground water will flow under the roadway, or at other



STORAGE AND LOADING PLANT
DELAWARE FEDERAL AID PROJECT NO. 4

places where seepage may occur. Lateral drains at an angle of about 60° with the roadway are constructed 50 to 75 feet apart on these long grades on project No. 1. These drains consist of 4-inch tile laid with open joints and covered with crushed stone to the surface of the subgrade.

On other projects, especially in southern Delaware, underdrainage gives little trouble, as the soil is of a sandy nature and does not retain storm water readily. On account of the low grades encountered in this section special outlet channels often are necessary. On many of the adjacent farm lands special channels have been provided for drainage purposes, and these are often used as outlets for the road drainage. Many of these special drainage channels have been constructed and maintained by special taxes levied on the benefited property. Where these waterways cross the highways careful study is given, so that ample openings may be left for these special channels. The elevation of culvert floors receives special attention with the view of providing sufficient fall for future drainage development and to prevent ponding of storm water.

Bridges and culverts usually are constructed of reinforced concrete. For waterways of 7 square feet or less reinforced concrete pipe generally is specified. Vitrified tile is used occasionally instead of reinforced concrete pipe. All pipe culverts are protected with concrete headwalls. Reinforced concrete box culverts and beam spans are used for openings of from 3 to 18 feet in length. For longer spans T girders and arches of reinforced concrete are used. The clear roadway for culverts and bridges varies from 32 to 40 feet in width. All such structures on project No. 1 have roadways of 40 feet. Substantial reinforced concrete guard rails and hub guards are provided on all spans of more than 6 feet. It is the practice to place the bridge floors below the finished subgrade so that the roadway or pavement may be constructed over the structure without any change in general construction features.

PROJECT NO. 1.

Delaware's first project, No. 1, known as the Philadelphia Pike, is the most heavily traveled highway in Delaware. It begins at the eastern corporation line of Wilmington and extends northeast to the Delaware-Pennsylvania line, a distance of 6.21 miles. The preliminary investigations of the State highway department showed that this road was receiving in 1917 an average of 35,000 gross tons per week. Locally, the project serves sections principally utilized for residential purposes. There are also a number of industrial developments to be served, and it is thought that these will increase in the future.

As a State highway it will serve as an outlet to northern markets for the products of the agricultural sections of Delaware. Traffic from this source will greatly increase with the completion of the State highway from Wilmington south. The project is also a very important interstate highway carrying a greater portion of the through north-and-south traffic. Traffic from Philadelphia to the south by way of Baltimore and the Maryland system of roads to the Shenandoah Valley, by way of Washington and Richmond, or by way of Cape Charles and Norfolk would pass over this project. Due to

FINISHING THE SUBGRADE ON DELAWARE PROJECT NO. 4. NO MATERIALS LOST AND THE SUBGRADE UNIFORM.

its importance in this respect, the State highway department has used every effort to secure its early improvement.

COST UNUSUALLY HIGH.

Contracts for section A, 5.72 miles, were awarded in May, 1917, and amounted to $639,349.59. While the price of road is unusually high, $111,774.23 per mile, it should be borne in mind that these contracts were let during war times in a section of the United States where labor was in great demand and that being a road of comparatively wide section the quantities of work to be performed are larger than ordinarily. Earth excavation and borrow amount to 53,000 cubic yards and in addition to this 14,500 cubic yards of rock excavation are required. Prices for the earth excavation were $1.62 and $2 and the rock $3.72 and $5 per cubic yard. Concrete base was awarded at $14 and $14.25 per cubic yard and vitrified brick (not including base) $2.50 to $3.50 per square yard. The unusual hazards due to war conditions undoubtedly affected the prices of the work.

The typical section illustrates the character of the improvement. It is the standard semimonolithic brick pavement. The specifications for the base require a 1:2½:5 concrete with the addition of 0.1 cubic feet of hydrated lime per bag of cement. A mix of one minute in the drum and a minimum of 15 revolutions also is required. The 1-inch cement-sand cushion course is in 1:3 proportions and the grout filler 1:1½ proportions.

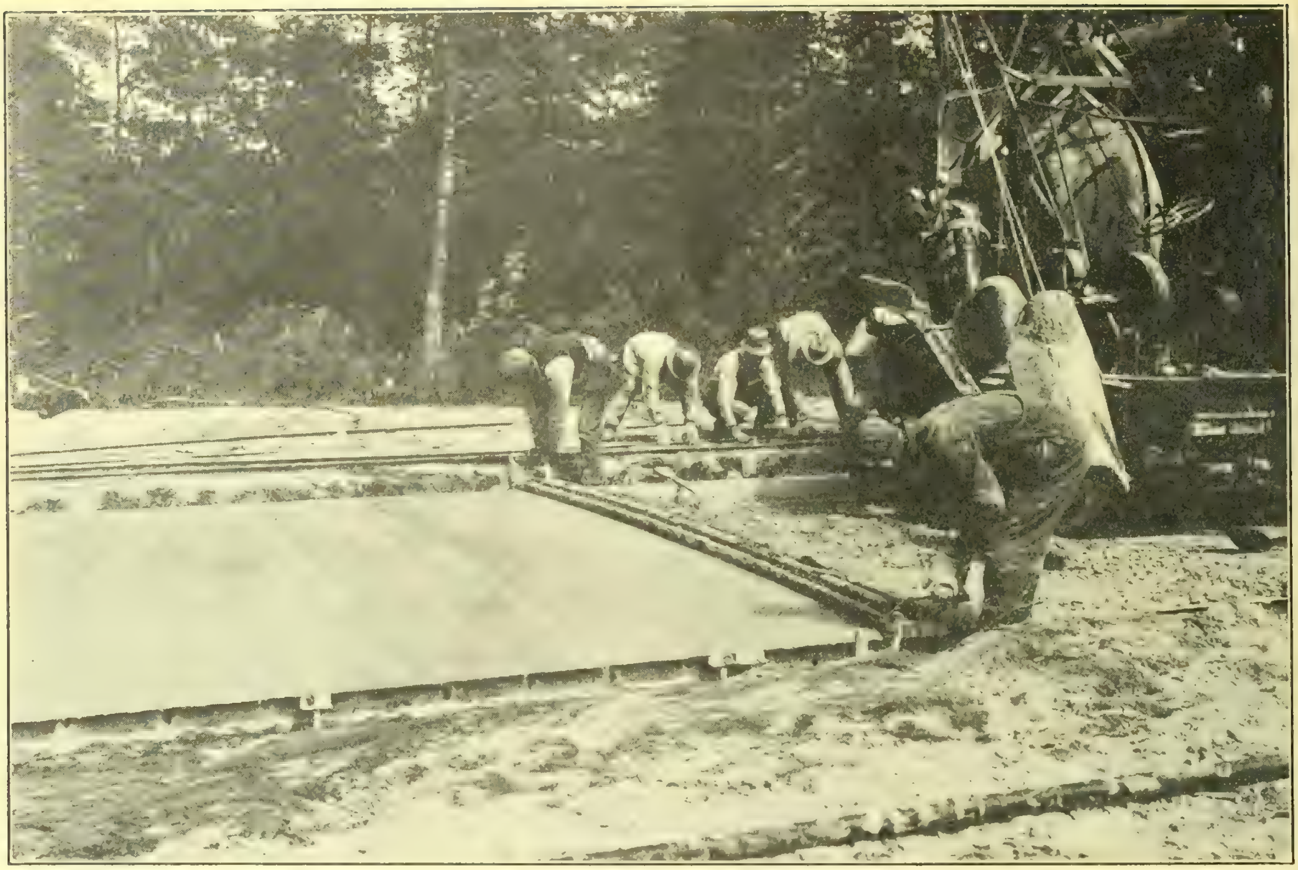
Specifications for the brick require a wire-cut vitrified paving block which will lose not more than 22 per cent in weight when submitted to the standard rattler test. On one contract Bessemer brick is used and in the other one Clydesdale. Plant inspection and test of the brick were made by the State highway department. Check tests from field samples also were made. The requirements of the specifications for hand piling of brick were waived by the State highway department to facilitate the rapid handling of freight cars, and the contractors dumped the blocks on the roadside. The brick were dumped from trucks against a sloping bulkhead, which it is believed greatly reduced the amount of spalling. The results of this method were satisfactory.

SECURING SMOOTH FINISH.

In laying the cement-sand cushion course, care was taken to eliminate all inequalities of the base and secure a smooth finished surface. To accomplish this, ''finish grade'' was marked on the curbs at intervals of 10 feet.

Because of the great changes in grades in a number of places it was necessary to lower much of the long-distance telephone cables in conduit along the project. Serious objections were made by the owners of these lines to making such changes during the stress of war times, as it was feared interruptions of the service might result. In some cases the conduits were lowered as much as 13 feet. Temporary cable lines were put up to by-pass the work. Blasting on the heavy rock work was done within 8 feet of the conduit without injury to the tile.

The material from the old roadway, mostly surface-treated macadam, is being used as shoulder material for the new construction. As rapidly as sections of the project are completed they are opened



THE 400-POUND TEMPLATE IN USE ON DELAWARE FEDERAL AID PROJECT NO. 4.

to traffic, so as to relieve as much as possible the lighter built detour roads.

Section 1B of this project, being 0.492 mile in length, was not placed under contract until April of this year. The State highway department expects the completion of the entire project by August of this year.

PROJECT NO. 2.

The State's second project is a part of the main north-and-south State highway and extends from Bridgeville to Laurel, a distance of 11.52 miles. Contract for this work was awarded in May, 1918, for the sum of $537,827.40. The project serves locally an agricultural community, but when the highway is completed to Wilmington this project will be a portion of an important through line for traffic from southern Delaware, the Eastern Shore of Maryland, and through traffic by way of Cape Charles and Norfolk.

The country through which the road passes is quite flat. Earthwork amounts to about 5,000 cubic yards per mile, and the contract price is $1.50 per cubic yard. The contract price on concrete roadway is $17.50 per cubic yard.

This project and project No. 4 are identical as to type and standard of construction.

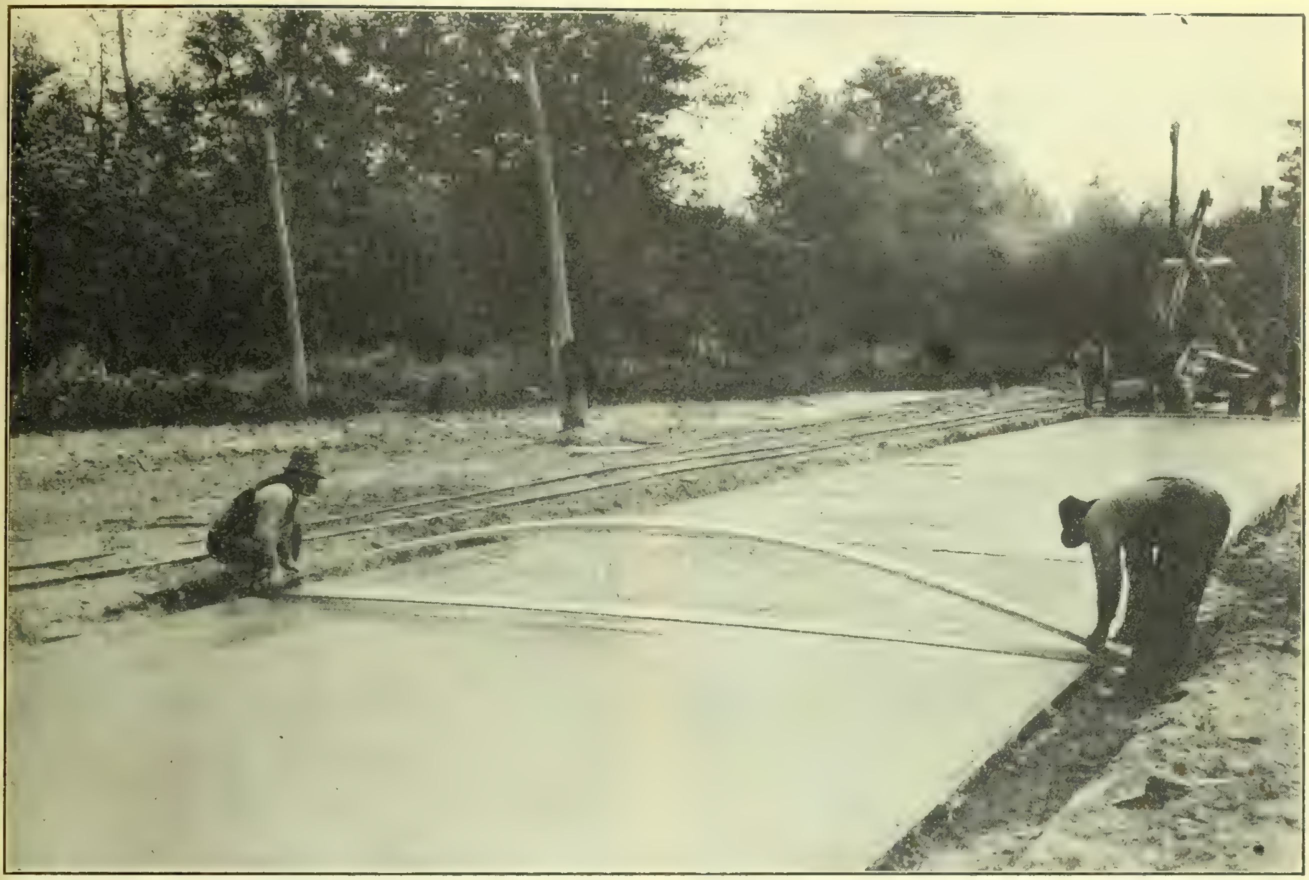
The specifications for the concrete require the proportions of 1 : 2 : 4 with the addition of 0.1 cubic foot hydrated lime per bag of cement. The use of hydrated lime is based on extensive experiments conducted by the State highway department. Mixing must be carried on for a period of at least one and a half minutes with a minimum speed of the drum of 15 revolutions per minute. The practice is to use the minimum amount of water which will give a concrete that can be properly worked and finished.

Special attention is given to securing a smooth, compact, uniform finish. To obtain this the concrete is worked down with shovels immediately ahead of the template, which is worked forward with the usual sawing motion. Practice has been to develop a heavy template. The template used this season weighs 400 pounds for a 16-foot roadway. By using a template of this weight it is not lifted readily from the side forms and consequently in working forward it cuts a fairly uniform surface.

USE SPECIAL FINISHING BELT.

For removing excess water and for finishing the concrete surface the standard practice of using a roller and belt is followed. For the past year a special arrangement for the finishing belt has been used in Delaware. It is a bow-belt 10 inches wide and 17 feet long attached to two 3 by ⅝ inch boards bowed so that the apex of the arc is 3 feet above the four-ply belt. Rubber belting is preferred to canvas, as the latter is liable to warp out of shape. C. S. Gale, engineer of construction for the State highway department must be given considerable credit for this form of belt finisher, and also for the heavier template now being used.

Joints are placed in concrete roadways only as construction features. At the end of each day's work a joint is made by finishing the concrete against a bulkhead cut to conform to the finished cross section of the road. Through this bulkhead



USING THE SPECIALLY DEVISED 10-INCH BOW BELT ON DELAWARE FEDERAL AID PROJECT NO. 4.

five ½ inch steel bars 4 feet long are extended for half their length into the concrete. These bars are coated with asphalt before being placed in the concrete. When the work is resumed the bulkhead is removed and the new concrete placed against the old, embedding the exposed portions of the bars. The joint thus formed is simply held in a vertical plane, the bars acting merely as dowels, allowing opening of the joint in a horizontal plane but no separation of the slabs vertically.

ROADS OPENED AFTER 30 DAYS.

The finished concrete is first protected by canvas and then with 2 inches of wet earth for 14 days. Concrete roadways are not opened to traffic until 30 days have elapsed from the time the concrete was placed.

Construction methods on this project are along the lines usually followed in this type of roadway. Grading generally has been completed, except for subgrade finishing, well in advance of the placing of concrete. Coarse aggregate is delivered by rail and a clam shell bucket is used for unloading the cars. The material is stock piled or placed in a bin which discharges directly into trucks. The stone is stock piled along one side of the road on the shoulder so as not to interfere with setting forms. Sand is hauled from a local pit and dumped on the subgrade as needed. A loader is used instead of wheelbarrows to measure and deliver the aggregate to the mixer skip. When not mixing concrete this loader is sometimes used for loading sand from the pit or for loading excavation or borrow into trucks.

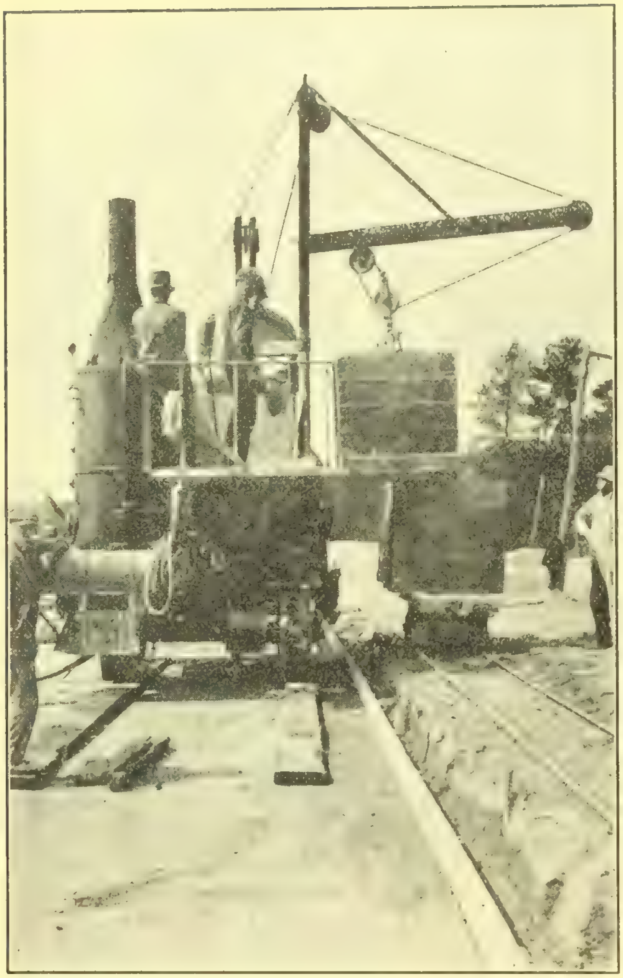
PROJECT NO. 4.

Project No. 4 is practically a continuation of project No. 3, extending from Laurel to the Delaware-Maryland line. A portion of this, however, was built before Federal aid was applied for and is not a part of the Federal-aid project. Contract for this work was awarded in May, 1918, at a contract price of $237,400 for 6.3 miles.

The general plans and specifications are the same as for project No. 2, but the method of construction differs materially. All materials are received at a central storage and loading plant and are sent direct to the mixer in batch units by means of industrial railway equipment. A general plan of this storage and loading plant is shown in the accompanying drawing.

Stone and sand are received in open cars on the railroad siding (track "A") and are unloaded by means of a clam-shell bucket and derrick working on track "B." The material, if for immediate use, is placed in the bins, which are also operated on track "B" or placed in storage piles for future use. Cement is also received on track "A," and if for immediate use is unloaded onto movable platforms that can be quickly set up conveniently near the car. If the cement is for future use, it is placed in the cement storehouse, from which it is placed on temporary platforms for use as needed.

A train to be loaded receives sand and stone on track "C" by passing under the material bins, where the proper amount of each material is dumped into batch boxes. Each car carries two boxes, and a box holds a batch of aggregate. Cement and lime



HOISTING A BATCH FOR DUMPING INTO THE MIXER DRUM ON DELAWARE FEDERAL AID PROJECT NO. 4.

EIGHTEEN-INCH BRICK, MACADAM SHOULDERS, UNFINISHED, ON DELAWARE FEDERAL AID PROJECT NO. 1.

are received from track "D", the cement being left in bags until the mixer is reached. Tracks "E" or "F" are used to reach the mixer, depending upon its location.

Upon reaching the mixer the boxes are hoisted from the cars and dumped directly into the mixer drum. The time required for making the hitch, hoisting and dumping the box, and replacing it in the car is one and one-half minutes. The mixer is an ordinary machine remodeled to handle the boxes. The skip has been taken off, but the skip hoist is used to raise the boxes. The mast is an extra heavy 5-inch iron pipe filled with cement mortar and the boom is made up of two 6-inch channels. The mast is stepped into a casting over a worm gear and can be turned through an angle of 160°. This special attachment for handling the boxes was put together by the contractor. The hitch for lifting the boxes is simply a yoke with links on each end which engage strap-iron hooks on the boxes.

The advantages and disadvantages of this method of handling and transporting materials for road construction are generally well known. All special equipment, such as batch boxes, mixer hoist, and stone bins, were made by the contractor and used with his regular construction equipment.

At the present time the contractor has a force of 67 men and the following equipment: One concrete mixer of 1 cubic yard capacity, 2 gasoline dinky engines, 42 cars, 84 loading boxes, $3\frac{1}{2}$ miles narrow-gauge railway, 1 steam roller, 10 teams, 2,500 linear feet steel side forms, and in addition the loading-plant equipment.

PRICES THIS YEAR ARE LOWER.

Projects Nos. 3 and 5 have been awarded recently at the prices given in Table No. 1. Some of the unit prices on this work are worthy of note in comparison with prices on similar work awarded last year (projects 2 and 4). The price for excavation was $0.676 per cubic yard and the price for cement roadway was $13.50 per cubic yard. These are about 45 per cent and 70 per cent respectively of last year's prices.

Recent changes in Delaware practice for the construction of concrete roads are principally the following: Use of the bow belt for finishing, using a 10-inch rubber belt; use of a 400-pound template with a minimum face of 8 inches, and requiring a batch meter for mixers on all new contracts.

At the present time the State highway department is revising its standard specifications and these are among the changes that will be made. The question of using a roller of larger diameter for finishing the concrete is now being considered, as is also the use of more rigid types of steel forms.

SUGGESTIONS FOR CONTRACTORS ON CONCRETE ROAD CONSTRUCTION

By CLYDE E. LEARNED, Highway Engineer, Bureau of Public Roads.

THE following notes and suggestions, compiled from long observation and practice in the construction of concrete highways, are offered with the view to affording aid to contractors and others engaged in such work.

Never attempt to build a concrete pavement unless you already have built one or have in your organization at least one good foreman thoroughly acquainted with this type of construction.

Troublesome equipment, especially the principal items such as the mixer and the pump, often will cause delays that are more costly than interest on new equipment. Therefore, in all cases where used equipment is employed, it is advisable to see that all is thoroughly overhauled and put into good running order before starting work. If the job is a large one, especially if isolated from repair shops, it usually will pay to consider carefully the purchase of new mixer and pump.

The cables on the mixer, as well as various parts on the mixer, the pumps, and other machines, are subject to rapid wear. To avoid delays caused by the breakage of such parts, spares should be kept on hand or under order at all times.

Have on hand at all times a list of repair parts and the nearest agencies for each machine.

CAREFUL OVERHAULING SAVES MONEY.

Keep all nuts on the mixer tightened and use plenty of oil and grease. It is money well spent to have the machinist spend ample time in carefully overhauling, cleaning, and adjusting all machines on the job.

Use a well-laid loop in feeding the mixer. By laying a 3 by 6 foot platform in front of the skip and by properly placing the runways a large skip can be loaded in a surprisingly short time.

In soft ground it will be necessary to provide runways for the wheelbarrow men and for the mixer itself. In fact, it is always better to have runways, but where they are used ample room should be provided at the skip for turning and there should be no drops onto or off of the runways.

Have the material that is distributed on the road ahead of the mixer properly placed, as considerable delay is caused when wheelbarrow men have to wheel materials a long distance.

Place a reliable man in charge of receiving and placing materials and do not depend upon the teamsters or the truck drivers to allocate them properly. Dump wagons and trucks often cut up the subgrade, with the result that more or less material may be lost in the ruts. This loss can be largely eliminated by having a laborer fill any ruts where a load is to be dumped.

TAKE CARE OF THE SUBGRADE.

Many contractors do not pay enough attention to the preparation of the subgrade or to taking care of it after it has once been shaped up, with the result that they have costly delays at the mixer and much unnecessary expense in reshaping the subgrade. If enough care is exercised in these particulars it usually is possible to eliminate the one or two men working on the grade ahead of the mixer.

Figure the proper spacing of the loads before cement is piled along the road ahead of the mixer.

Have the cement dumped on the opposite side of the road from the pipe line.

Shake out and tie up cement sacks as they are used. A man will shake enough cement out of the bags to more than pay his wages.

Have the sacks gathered up every night rather than left in piles along the road.

Have boards placed under any cement that is to be left out over night and have enough canvas on hand to cover it in case of rain.

If side forms are to be used, grade the road so that the shoulders will not interfere with placing them.

Where wooden side forms are to be used over and over it will save money to cap them with angle irons.

If motor trucks are used for hauling, it generally will be advisable for them to back in to dump their loads.

ECONOMY IN USE OF TRUCKS.

For hauling the materials for a concrete road it is more economical to use trucks with a capacity of from 3½ to 5 tons than trucks of a smaller capacity unless local soil conditions make the operation of such large trucks inadvisable.

A small-capacity truck often proves economical for hauling cement, as it can be driven between the material piles on the road and has comparatively little tendency to damage the subgrade.

Before buying a pump do a little figuring, taking into consideration the size, length, and condition of the pipe line to be used, the maximum vertical height to which water is to be raised, the amount of water that will be required, and the source from which it must be obtained. When the supply is from a deep bored well it will be necessary to provide an extra pump for lifting the water from the well. This should be a deep-well pump connected to an appropriate engine. It is used to pump the water into the storage tank or reservoir from which the high-pressure pump draws the water for the mixer.

Do not use less than a 2-inch pipe line, and discard all defective lengths and rethread all poor ends before laying it.

WATER REQUIREMENTS.

The water requirements will vary from 20 gallons to as much as 60 gallons per minute. This includes water for the concrete mixing, for wetting the subgrade, and one stream for curing the concrete. Usually one stream is not enough to keep the green concrete in good condition, so it will often be necessary to resort to night pumping to provide enough water for this purpose.

The following tables will be of assistance in determining the size of pump required for most conditions:

Table I.

Water required per minute.	Loss in friction head (in feet) in 2-inch pipe.			
	1 mile.	2 miles.	3 miles.	4 miles.
20 gallons	51	102	153	204
30 gallons	110	220	330	440
40 gallons	194	388	582	776
50 gallons	296	592	888	1,184
60 gallons	468	936	1,404	1,872

To the loss in head in the above table it will be necessary to add the vertical height that the water is to be pumped and to make allowance for angles and valves.

The theoretical horsepower required to raise water to different heights is given in the following table:

Table II.

Per minute.	Height to be raised (in feet).					
	100	200	300	400	500	600
20 gallons	0.50	1.00	1.50	2.00	2.50	3.00
30 gallons	.75	1.50	2.25	3.00	3.75	4.50
40 gallons	1.00	2.00	3.00	4.00	5.00	6.00
50 gallons	1.25	2.50	3.75	5.00	6.25	7.50
60 gallons	1.50	3.00	4.50	6.00	7.50	9.00

Multiply theoretical horsepower by 4 for deliveries of 30 gallons per minute or less and by 3 for deliveries of from 30 to 125 gallons per minute.

Example.

Required, 40 gallons per minute; maximum distance to be pumped = 2 miles, up a hill 100 feet in height.

From Table I:
Loss in head in pipe line........................ = 388 feet.
Vertical height up hill........................ = 100 feet.
Estimated loss of head in valves, elbows, etc.. = 20 feet.

Total head........................ = 508 feet.
From Table II:
Theoretical horsepower required.............. = 5 horsepower.
Actual horsepower required for engine and pump, three times theoretical horsepower... = 15 horsepower

RELIEF VALVES TO PREVENT DAMAGE.

The vertical distance from the water surface to the pump should not exceed 20 feet, and a foot valve should be placed on the end of the suction pipe. To prevent damage from excessive pressure in the line all pumps should be provided with relief valves.

Provide a 1-inch hose from pipe line to mixer.

At the pump provide a check valve in the main pipe line, and between it and the pump put in a tee with a short nipple, on which a globe valve is set. Open the globe valve before starting the pump, allowing the water to discharge into the air at this point. Close the valve as the engine gets up speed.

Globe valves should be provided in the pipe line about every 1,000 feet apart, 2-inch to 1-inch tees from 200 to 300 feet apart, and unions about 500 feet apart.

The insert for the mixer should be made up as follows: A 1-inch short nipple, a 1-inch globe valve, and another 1-inch short nipple, to which the mixer hose is coupled.

The hose for wetting down the concrete usually is 1-inch size, as it is easy to drag around. The inserts are made by using a 1-inch nipple, then a 1-inch square-head cock, and then another 1-inch short nipple. About a dozen of these inserts should be provided, and they should be moved from place to place as the progress of the work requires.

CARE IN LAYING PIPE LINE.

In laying the pipe line eliminate sharp sags and raises as much as possible, for air pockets at the high points will cause much trouble. If an extra tee is placed at each high point, a nipple inserted and a valve attached, the air pockets can be blown off readily. Provide a similar outlet at all low spots in order that the pipe may be drained if occasion requires.

Two men can lay 1,500 to 2,000 feet of good pipe a day.

If the size of the job warrants it a blacksmith shop will save considerable time. Provide it with a blacksmith's outfit, a strong bench vise, a drill press, and a supply of various sizes of round and flat iron.

Use white lead or a mixture of graphite and machine oil for connecting pipe line. Machine oil is preferable if the pipe is to be taken apart frequently.

When a split or a leak occurs in the pipe line mark it with red lead, so that it will be noticed, and cut out the defective section before laying the pipe again.

Provide a good grade of 1-inch hose for general use on the work.

The following list of tools and supplies are recommended for repair work on the concrete mixer and pipe line:

Hinge pipe vise and bench (light and movable).

Pipe cutter, pipe dies, and holder.

Breast drill, with assortment of bits.

Cold cutters, cold chisels, and hacksaws.

Wrenches—monkey, Stillson, Westcotts, open-end, etc.

Hose menders and couplings.

Pliers and end-cutting nippers.

Rubber packing, electric tape, and candle wicking.

Assortment of carriage and machine bolts.

Extra supply of valves, tees, ells, unions, couplings, nipples, plugs, and reducers.

Rolls of 18-gauge wire for bundling cement sacks.

PEOPLE LIKE GOOD ROADS.

Outagamie County, Wis., in 1916 voted a bond issue of $700,000 for the construction of a system of concrete roads. The issue was not large enough to complete the system, but the roads built proved so successful in educating the public that the county board in 1917 issued additional bonds to the amount of $260,000 for highway work, and recently a resolution was passed by the board for a third issue, of $160,000. At the end of this year Outagamie will have 75 miles of concrete roads.

A BIG PROGRAM FOR 1919.

From March 20 to May 2 contracts were awarded by the Pennsylvania State highway department for 249.11 miles of the State highway system. Bids will be opened June 17 for 65 miles, in various parts of the State, and contracts will be let for an additional 150 miles before July 15. This will make a total mileage of 464.12 of main State highways contracted for and on which work will be done this year. In addition construction work is under way on 137.46 miles for which the contracts were let in 1917 and 1918, bringing the total length of roads completed or under way this year to over 601 miles.

It is asserted that this work will break all records for highway expenditure and length of construction planned. The contract price for the 195 miles of road for which contracts were let from March 20 to May 2 is $7,277,634.68. The roads are 18 feet wide. Practically all the roads are concrete, reinforced concrete, or bituminous surface.

TO BUILD PAVED HIGHWAY.

The board of revenue of Jefferson County, Ala., is considering the construction of 20 to 30 miles of permanent paved highway this year. The road will have a concrete base with brick, asphalt or other surface. The county now has about $300,000 in its road and bridge fund and expects to receive as much more State and Federal aid. The question of issuing county bonds to the amount of $5,000,000 is being considered.

NEW NEBRASKA ROAD LAWS.

The 1919 Nebraska Legislature passed several important laws relating to highways. The most important provides for a system of State highways, to include 79 new road sections in addition to 9 previously laid out, to be constructed and improved with State and Federal funds. The State engineer is required by January 1, 1920, to file with each county clerk a map showing all the State highways within the county. The State highways department will build the roads. The counties are required to maintain them and to provide markers. Provision was made for dividing the State into project districts, with not more than five counties to a district.

The use of the State highways is prohibited to motor vehicles over 7½ feet wide or 12 feet high, and vehicles with a load limit exceeding 600 pounds for each inch width of wheel tire are also barred. A truck carrying over 7,000 pounds combined load on any one wheel can not use the highways without special permission of the State highways board. Advertising signs upon or along the State highways are forbidden except by written permission of the board and after a fee ranging from 25 cents to $5 is paid.

Motor-license fees were raised. Twenty-five per cent of the fees received are set aside for the county road dragging fund, the balance deposited with the State treasurer to the credit of the State highway fund to be expended for road improvement in the county from which it is collected.

A State-aid road fund was created and a tax of 3 mills levied for the years 1919 and 1920. Appropriations were made from this fund for each of the two years to the amount of $1,546,631 to match an equal amount of Federal-aid funds.

The legislature authorized the publication of the Monthly Highway Report, the first number of which appeared in May.

BONDS FOR HIGHWAY.

Sussex County, Del., will issue bonds to the amount of $500,000 to construct a concrete road across the county from Lewes and Rehoboth Beach to the Maryland line.

GOOD ROADS IN ALABAMA.

According to the records in the office of State Highway Commissioner Keller, of Alabama, nearly every county in the State has taken advantage of State aid in the building of roads, and a rapidly increasing number have taken up the Federal-aid proposition. Only one county has not yet taken up State or Federal aid. A large amount of road work is under way or planned in Alabama, and the year will see a large mileage added to the improved highways of the State.

11,326 MILES OF FEDERAL-AID ROADS IN APPROVED PROJECTS

IN MAY new records were made in the number of new Federal-aid projects approved, in the number of project agreements executed, and in the estimated cost of the projects and the amount of Federal aid asked and allowed. In 123 new project statements approved and in revision of two previously approved the Federal aid asked amounts to $6,428,418.79 for roads estimated to cost $15,203,873.06, and which will have a mileage of 762.943. Agreements were executed for 81 projects and modifications made in 21 projects previously executed. The aggregate length of the roads embraced in these agreements is 670.342 miles and the estimated cost $6,400,912.05. Total Federal aid allowed is $3,907,232.66.

The figures for both statements approved and agreements signed during the month show 226 projects with a mileage of 1,433.342, an estimated road cost of $23,604,785.11. The total Federal aid involved amounts to $10,335,651.45.

Since the Federal-aid law was passed, 1,186 projects for 11,326.356 miles of road have been approved. The estimated cost of these projects is $108,059,783.40, and they call for Federal aid to the amount of $42,929,483.83. The total number of agreements executed up to June 1 was 617 for 5,286.125 miles of road, with a total Federal-aid allowance of $19,521,162.27, and an estimated cost of roads of $47,425,729.28.

The estimated cost of roads in the applications for Federal aid received in May is $19,192,135.05, almost one-sixth of that of all the applications since the first one was received under the law.

In the number of project statements approved during May, Georgia and Ohio were the leading States, the former with 17 and the latter with 16 projects. In the amount of Federal aid involved Ohio led, with a total of $884,800, and Pennsylvania followed, with requests for a total of $822,871.60 for 6 projects. These States were also leaders in the estimated cost of the roads, the figures being $2,881,479.38 and $2,135,861.05. The Ohio cost is for 77.93 miles of road and Pennsylvania's for 40.87 miles. Nebraska's projects have the greatest aggregate mileage, 104.55, with the total for Georgia, 103.20, almost as great.

In five States the estimated cost of the projects approved amounts to more than $1,000,000. In addition to Ohio and Pennsylvania they are Maryland, California, and Washington, while the Georgia amount is above $900,000. These six States represent the East, the Middle West, the South, and the Pacific coast, indicating the country-wide movement of the road-building program.

The average cost of the Pennsylvania roads included in the projects approved is $52,260 a mile. On one project the average will be $59,323. One Ohio project will average about $58,560 a mile.

The largest project approved during the month, in cost and Federal aid involved, is for 11.6 miles of bituminous and concrete road in Luzerne County, Pa., the estimated cost of which is $618,124, for which $232,000 of Federal aid is requested. Another Pennsylvania project, 7.6 miles of concrete in Berks and Schuylkill Counties, will cost $426,750, and an allowance for it of $157,471.60 is asked. A 25-mile earth road in Mendocino County, Calif., is estimated to cost $387,805, with Federal aid of $193,902.50.

In the agreements executed during the month Federal aid to the amount of $1,192,386.26 was allowed to 11 Pennsylvania projects, estimated to cost $2,770,550.43. They represent 61.16 miles of highway. New Jersey and Nebraska are second and third in amount of Federal aid allowed, $256,666.28 and $249,419.59, respectively, for roads estimated to cost $570,369.53 and $502,839.20.

RECORD OF FEDERAL-AID PROJECTS IN MAY, 1919.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	22	Colbert	0.69	Gravel, bituminous surface treatment, or chert or slag macadam, bituminous surface treatment.		May 27	$10,511.87	$5,255.93
	37	Jackson				May 5	[1] 478.13	[1] 639.07
	38	Lawrence	7.38	Gravel		May 26	49,779.77	24,889.88
	41	Pike	6.89	Sand-clay		May 27	30,946.35	15,473.17
	43	Covington	4.12	do	May 7		33,440.00	16,720.00
	46	Jackson	6.00	Macadam	May 19		28,589.13	14,294.56
	47	Butler	3.37	Sand-clay	May 31		26,438.78	13,219.39
	48	Barbour	8.66	do	May 12		41,583.30	20,791.65
Arizona	8	Maricopa	6.84	Concrete or bituminous	May 1		207,888.12	103,944.06
California	14	Mendocino	25.00	Earth	May 9		387,805.00	193,902.50
	15	Monterey	1.03	Bridge and concrete	May 31		304,062.00	152,031.00
	16	Humboldt	2.80	Earth	May 29		43,073.25	21,536.62
	17	Del Norte	7.91	do	do		241,802.00	120,901.00
	18	Humboldt	7.94	Concrete	May 27		142,883.40	71,441.70
Colorado	9	Larimer	19.014	Earth		May 23	89,924.95	44,962.47
Connecticut	3	New London	7.83	Bituminous macadam		May 8	256,145.23	128,072.61
	5	Fairfield	11.183	Bituminous	May 7		315,810.00	157,905.00
Florida	13	Orange	8.67	Concrete	May 12		153,370.80	76,685.40
	14	Santa Rosa	5.923	Brick or concrete	May 5		166,408.66	83,204.33
	15	De Soto	3.26	Concrete	May 26		54,570.67	20,000.00
	16	do	.67	do	do		11,798.80	5,899.40
Georgia	14	Floyd	7.444	Topsoil		May 26	28,524.39	14,000.00
	17	Harris	19.95	Earth, surfaced with topsoil in part.		do	107,725.98	53,500.00
	24	Cherokee	[2] 2.05	Gravel and topsoil		May 2	[2] 12,137.55	[2] 7,700.00
	35	Whitfield	5.80	Gravel	May 24		54,188.67	27,094.33
	55	Walker	23.30	do	May 7		144,762.13	72,381.06
	56	Gwinnett	11.80	Sand-clay	May 26		60,759.27	30,379.63
	59	Jackson	4.00	do	May 5		21,769.00	10,884.50

[1] Modified agreement. Estimated cost and Federal-aid allowance reduced from original figures by the amounts given.
[2] Modified agreement. Mileage or amounts given are increases over the original figures.

RECORD OF FEDERAL-AID PROJECTS IN MAY, 1919—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Georgia	60	Stephens	11.20	Sand-clay	May 7		$51,218.64	$25,000.00
	61	Wilkes	2.10	Concrete	May 16		58,167.67	29,083.83
	62	do	.60	do	May 10		16,587.12	8,293.56
	63	do	.60	do	May 13		15,869.37	7,934.68
	64	Glynn	4.40	Brick or concrete	May 6		108,820.80	54,410.40
	65	Dade	2.00	Gravel	do		32,418.98	15,000.00
	66	McDuffie	.80	Sand-clay	May 5		11,073.96	5,536.98
	67	Green		2 bridges and approaches	May 6		63,176.48	31,588.24
	69	Franklin	11.90	Sand-clay	May 16		55,633.16	27,816.58
	70	Morgan	7.00	Concrete	do		106,843.18	53,421.59
	71	Catoosa	7.70	Gravel	May 23		45,499.81	22,749.90
	72	Elbert	10.00	Sand-clay	May 16		51,154.71	25,577.35
	73	Richmond		Concrete bridge and approaches	do		12,584.00	6,292.00
Idaho	11	Elmore	28.00	Gravel	May 29		262,823.00	131,411.50
Iowa	8	Decatur	9.80	Graded earth		May 9	60,320.90	30,000.00
	20	Monroe	8.25	Earth		do	48,639.07	24,000.00
Kansas	4	Shawnee		Concrete		May 13		[1] 37,400.82
	11	Sedgwick		do		do		[1] 35,776.99
	17	Geary		Brick		do		[1] 4,320.50
	25A	Wyandotte	2.50	Concrete			89,134.58	37,500.00
	26	Rice	7.31	Brick or concrete	May 23		337,720.90	109,650.00
Kentucky	3	Rowan	7.756	Graded and drained earth		May 27	73,775.88	36,887.94
Louisiana	25	Ouachita		Gravel		May 29	[1] 4,271.00	[1] 9,484.07
	29	Franklin	10.47	do		May 27	101,635.93	50,000.00
Maryland	8A	Talbot	3.11	Concrete		May 31	100,085.70	50,042.85
	12A	Frederick	2.007	do		May 8	59,008.40	29,504.20
	15	Baltimore	5.36	do	May 2		196,812.00	98,406.00
	17	Harford	4.50	do	May 6		142,890.00	71,445.00
	18	Cecil	2.08	do	May 2		80,506.25	40,253.12
	20	Dorchester	2.15	do	May 23		65,976.60	32,988.30
	22	Caroline	5.16	do	May 2		214,445.00	103,200.00
	26	Baltimore	7.37	do	May 19		233,750.00	116,875.00
	27	do	.93	do	May 29		73,975.00	18,600.00
	29	Worcester	4.55	do	do		176,000.00	88,000.00
	30	do	4.30	do	do		169,400.00	84,700.00
Massachusetts	4	Essex		Bituminous macadam		May 1		[1] 2,210.22
	8	Worcester	7.016	do		May 24	180,638.09	90,319.04
	11	Middlesex	4.849	Bituminous		May 16	158,212.45	79,106.22
	19	Bristol	2.116	Concrete	May 27		83,442.15	41,721.07
	20	Middlesex	2.909	Bituminous	May 26		77,505.45	38,752.72
Michigan	8	Allegan	.008	Bituminous macadam		May 22		[1] 9,199.56
	9B	Washtenaw	.124	Concrete or brick		May 5	7,715.40	2,480.00
	16B	do	.373	Concrete, asphaltic concrete, or brick.		do	23,777.16	7,460.00
	21	Kalamazoo		Concrete		May 22	[1] 24,488.81	[1] 15,999.08
	24	Berrien		Macadam, surface treated		May 5	[1] 36,588.66	[1] 14,719.41
	25	Delta and Schoolcraft	8.128	do		May 22	140,522.14	70,261.07
Minnesota	16	Anoka	20.46	Crushed rock		May 31	256,193.95	128,096.97
	23	Dakota	6.00	Concrete, brick, or asphalt	May 20		200,000.00	100,000.00
	26	Todd	4.80	Gravel	May 21		30,537.69	10,000.00
	27	Douglas		do		May 27	[1] 4,730.62	[1] 22,781.96
	44	Sherburne	4.50	Asphalt, brick, or concrete	May 27		136,688.03	68,344.01
Mississippi	5	Rankin	5.787	Gravel		May 31	53,482.94	26,741.47
	17	Hinds	4.119	do		do	30,950.38	15,000.00
	36	Walthall	9.239	do		do	53,754.50	26,000.00
Missouri	11	Callaway		do		May 23	[1] 9,088.60	[1] 4,544.30
	19	Jackson	2.40	Bituminous	May 10		89,809.41	44,904.70
Montana	3	Carbon	2.69	Gravel		May 2	17,550.77	8,775.38
	5	Big Horn	2.02	do		do	12,532.46	6,266.23
	6	Dawson	7.50	Gravel and shale surface		May 5	21,939.66	10,969.83
	7	do	9.00	Gravel		May 2	21,367.83	10,683.91
Nebraska	2	Richardson, Omaha, Otoe		1 mile gravel, rest earth		May 27	[1] 60,032.50	[1] 30,016.25
	12	Logan		Graded and drained earth		May 22	[1] 6,168.68	[1] 3,084.34
	21	Sheridan	14.83	Gravel		do	71,763.12	35,881.56
	23	Burt and Washington	33.30	Earth		May 31	107,792.65	53,896.32
	25	Gage and Jefferson	29.72	do		May 5	72,839.89	36,419.94
	26	Chase and Hays	16.90	do	May 5		51,480.00	25,740.00
	28	Cass and Otoe	26.19	do		May 22	71,269.00	35,634.50
	29	Butler	37.67	do		May 8	112,973.36	54,486.68
	38	Frontier	12.10	do	May 7		29,480.00	14,740.00
	39	Dawson	28.50	do	May 23		48,840.00	24,420.00
	41	Dundy	13.60	do	May 2		40,480.00	20,240.00
	45	Sioux	8.25	Sand-clay	May 12		45,804.00	22,902.00
	60	Hall and Howard	25.20	Earth	May 29		56,980.00	28,490.00
Nevada	9	Washoe	5.42	Concrete or bituminous		May 31	161,269.74	80,634.87
	21	do	1.00	Concrete	May 5		42,958.30	20,000.00
	22	Eureka	6.30	Gravel	May 23		89,900.53	44,950.26
New Hampshire	21	Cheshire and Coos	3.59	do	May 5		15,413.86	7,706.93
	23	Hillsborough	2.09	Gravel or macadam	May 26		29,984.46	14,992.23
	27	Grafton and Hillsborough	1.515		do		30,000.00	15,000.00
	38	Hillsborough	1.30	Bituminous	May 29		14,194.29	7,097.14
New Jersey	5	Atlantic	3.873	Concrete		May 15	146,091.00	65,740.95
	6	do	5.867	do		do	222,382.85	100,072.28
	8	Cape May	2.025	do		May 16	74,211.74	33,395.28
	9	do	3.575	do		do	127,683.94	57,457.77
	11	Atlantic	4.418	do	May 16		183,864.59	88,360.00
New Mexico	4	Valencia	20.62	Graded earth, surfaced where needed.		May 13	74,268.74	37,134.37
	19	Luna	10.25	Gravel	May 27		60,236.00	30,118.00
New York	8	Wayne		Bituminous macadam or concrete		May 5	[1] 41,990.00	[1] 20,995.00
	22	Broome	4.20	Bituminous	May 9		105,000.00	52,500.00
	24	Herkimer	2.26	do	May 12		56,500.00	28,250.00
	25	Madison and Oneida	5.70	Concrete	do		151,470.00	75,735.00
	26	Steuben	3.50	do	do		106,300.00	53,150.00
	28	Wyoming	7.90	do	do		243,900.00	121,950.00
North Carolina	17	Wilkes	17.60			May 6	101,386.08	25,000.00
	24	Wake		Concrete		May 5	[1] 62,029.55	[1] 39,894.77
	33	Montgomery	10.78	Topsoil		May 6	22,222.40	5,000.00
	35	Forsythe	1.87	Concrete		May 12	60,335.87	26,400.00
	42	Stanly	11.68	Sand-clay or gravel	May 29		62,392.00	16,700.00
	43	Beaufort	2.20	Concrete	May 26		79,651.11	39,825.00
	44	Granville	4.569	Sand-clay	May 27		31,362.10	15,500.00
North Dakota	32	Cass	.34	2 bridges		May 26	41,250.77	20,625.33
	43	Bottineau	10.00	Gravel	May 12		23,850.75	11,925.37

[1] Modified agreement. Mileage or amounts given are increases over the original figures.

RECORD OF FEDERAL-AID PROJECTS IN MAY, 1919—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Ohio	5	Lake		Reinforced concrete or brick monolithic.		May 8	[1] $12,830.00	[1] $3.00
	23A	Stark	4.83	Brick		May 31	240,000.00	81,580.00
	23B	do	3.21	do		do	162,000.00	54,220.00
	35	Portage	8.46	Macadam	May 24		245,300.00	84,600.00
	40	Medina	4.73	Bituminous or concrete	May 16		153,000.00	75,000.00
	41	Trumbull	9.897	Macadam or concrete	May 24		348,000.00	80,000.00
	42	Seneca	4.28	Bituminous, concrete, or brick	do		179,000.00	42,800.00
	43	Ottawa	7.14	Concrete	May 20		238,000.00	71,500.00
	44	Lorain	2.70	Brick or concrete	May 19		133,000.00	50,000.00
	45	do	1.21	Concrete	May 16		49,500.00	6,500.00
	49	Morgan	3.26	Macadam	May 29		82,000.00	41,000.00
	51	Sandusky	5.76	Brick or bituminous	May 19		337,000.00	86,400.00
	52	Huron	1.28	Brick	May 24		51,000.00	17,000.00
	55	Miami	3.59	Concrete	May 19		106,000.00	20,000.00
	57	Shelby	3.04	do	May 24		96,000.00	35,000.00
	58	do	3.52	do	do		106,000.00	35,000.00
	60	Holmes	10.00	Macadam	do		414,079.38	100,000.00
	65	Hancock	6.04	Brick, asphalt, or concrete	May 19		243,600.00	90,000.00
	80	Washington	3.026	Concrete	May 29		100,000.00	50,000.00
Oklahoma	9	Le Flore		Bridge	May 19		38,500.00	19,250.00
	10	do		3 bridges	May 26		129,536.00	64,768.00
	11	McClain and Pottawatomie		Bridge	May 29		200,000.00	100,000.00
Oregon	10	Baker	18.80	Earth		May 26	91,258.36	38,129.18
	12	Yamhill	2.75	Macadam		do	39,986.95	14,993.47
	18	Polk	[2] 7.00	Hard surface	May 7		[2] 171,963.00	[2] 93,548.00
	19	Marion	4.18	Concrete or bituminous	May 12		99,895.11	49,947.55
Pennsylvania	13	Armstrong	4.10	Reinforced concrete		May 8	216,792.29	82,000.00
	20A	Adams, Cumberland, York	5.21	Concrete or bituminous		May 5	225,348.47	104,200.00
	21	Lehigh	6.64	Concrete		May 9	264,111.85	132,055.92
	22	Monroe	4.45	do		do	155,790.14	77,895.07
	23	Greene	6.49	do	May 13		358,039.05	129,800.00
	24A	Warren	5.09	do		May 12	224,104.38	101,800.00
	25	Adams and Franklin	5.70	do		May 23	205,181.20	102,590.60
	26	Elk	5.62	do		do	274,093.60	112,400.00
	27	Allegheny	8.22	Bituminous		May 12	487,638.08	164,400.00
	28	Mercer	4.53	Concrete		May 9	170,280.04	85,140.02
	29	Pike	5.60	Bituminous concrete		do	219,809.31	109,904.65
	30	Bradford	6.00	Concrete		May 12	327,401.07	120,000.00
	31	Center	6.10	Bituminous and brick	May 16		291,060.00	122,000.00
	32	Chester	4.10	Concrete	May 15		181,720.00	82,000.00
	33	Luzerne	11.60	Bituminous and concrete	do		618,134.00	232,000.00
	34	Berks and Schuylkill	7.60	Concrete	May 16		426,758.00	157,471.60
	35	Tioga	4.98	do	May 12		260,150.00	99,600.00
Rhode Island	3	Washington		Bituminous macadam		May 21		[1] 8,443.00
South Carolina	8	Bamberg		Sandy-clay		May 31	[1] 9,101.40	[1] 6,740.75
	17	Calhoun	.22	3 bridges		May 10	18,423.51	9,211.75
	24	Spartanburg	1.90	Asphalt	May 19		55,192.50	27,596.25
Texas	17	Mason	24.877	Sand-clay and gravel		May 23	42,384.97	20,000.00
	28	Morris	10.70	Sand-clay		May 22	64,342.83	32,171.41
	36	Caldwell	15.67	Gravel		do	127,680.65	35,000.00
	39	Dallas	9.125	Concrete	May 12		365,469.20	58,000.00
	62	Foard	14.564	Gravel and sand-clay		May 22	32,379.34	14,616.89
	63	Fannin	7.12	Gravel		May 31	54,863.88	26,357.07
	75	Falls	1.10	do		May 22	11,957.64	5,978.82
	78	Freestone	17.22	Gravel and sand-clay		do	57,044.52	28,522.26
	80	Harris	9.269	Concrete and macadam	May 27		91,283.26	25,000.00
	81	Freestone	2.79	Gravel or macadam	May 23		40,421.58	20,000.00
Utah	34	Utah	5.74	Concrete	May 29		194,784.93	97,392.46
Virginia	20	Southampton	8.315	Gravel		May 29	183,140.54	91,570.27
	23	Charles City	4.14	do		May 13	18,824.30	9,412.15
	30	Roanoke	2.27	Macadam		May 29	33,634.15	16,817.07
	33	Nelson	2.68	do		May 13	34,936.00	17,468.00
Washington	17	Whatcomb	3.60	Concrete	May 12		99,812.90	49,906.45
	18	Skagit	5.57	Gravel	do		61,380.55	30,690.27
	19	Jefferson	3.49	do	do		46,999.15	23,499.57
	20	Spokane	7.80	Gravel or macadam	May 27		81,051.98	40,525.99
	21	Grant	4.89	do	do		42,642.71	21,321.35
	22	Spokane	4.50	Concrete	do		118,597.60	59,298.80
	23	do	3.88	do	May 26		108,618.84	54,309.42
	24	King	6.42	do	May 21		187,484.00	93,742.00
	25	Thurston	7.00	do	do		213,075.50	46,537.75
	26	Grays Harbor	3.17	do	May 23		85,360.00	42,680.00
West Virginia	20	Doddridge	.57	do		May 23	20,353.30	6,700,00
	22	Hancock	1.05	Brick on concrete base		May 5	24,851.75	10,500.00
	23	Kanawha		Asphaltic concrete		May 23		[1] 10,000.00
	25	Lincoln	4.50	Concrete		May 16	89,503.01	40,600.00
	27	Barbour	3.14	Macadam		May 15	59,614.50	29,000.00
	28	Tyler	1.50	Concrete		do	40,903.00	20,451.50
	37	Marion	.76	do	May 12		32,979.92	15,200.00
	38	Fayette	6.00	Bituminous	do		103,248.20	44,200.00
	42	Raleigh	5.24	do	May 31		53,674.86	26,766.00
	43	do	1.43	do	May 29		17,180.02	8,590.01
	44	Mercer	6.00	Macadam	do		80,707.20	40,350.00
Wisconsin	31	Taylor	[2] 3.52	Earth	May 27		[2] 16,194.06	[2] 5,398.02
	42	Rock	[1] 2.89	Concrete		May 22	[1] 64,854.98	[1] 19,198.99
	46	Waushara	10.187	Earth		do	32,912.50	10,970.83
	49	Waupaca	9.54	Earth, surfaced in part		do	31,986.09	10,662.03
	51	Columbia	5.05	Gravel or macadam	May 31		72,613.24	24,204.41
	53	Vilas and Iron	13.51	Earth and gravel	May 7		69,518.73	23,172.91
	65	Winnebago	.25	Concrete		May 31	5,154.20	1,718.07
	68	Wood	4.63	Gravel		May 22	24,943.16	8,314.39
	72	Dodge and Jefferson	3.53	do		May 21	38,417.01	12,805.67
	73	Forest	4.47	do		May 13	23,997.39	7,999.13
	75	Price	6.06	Gravel and earth		May 22	21,436.41	7,145.47
	81	Trempealeau	4.74	Gravel	May 12		68,266.11	22,755.37
	82	Vernon	2.96	Bituminous	May 14		46,207.41	15,402.47
	91	Rusk	6.80	Earth	May 24		26,639.14	8,879.71
Wyoming	20	Sheridan		Concrete or asphaltic		May 9	[1] 52,481.09	[1] 31,054.81
	36	Albany	15.00	Natural gravel	May 31		29,915.60	14,957.80
Total	227		1,433.352				23,604,785.11	10,335,651.45

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[1] Modified agreement. Mileage or amounts given are increases over the original figures.

[2] Revised project statement. Figures given show amount of increases over the original statement.

ROAD MAKING AT FRONT IN FRANCE

By F. G. EASON, Senior Drainage Engineer, Bureau of Public Roads, Captain Company A, 317th Engineers, U. S. A.

THE ROAD THROUGH NO MAN'S LAND, FOREST OF ARGONNE.

IT was very instructive, as well as interesting, to attend the 188 various schools conducted in France by the Army for the purpose of imparting the best methods of constructing roads and other engineering works at the front during active operations. It was also most amusing to see the way all of these technical methods were "shot to pieces" under actual working conditions at the front. It resolved itself into a question of simply doing the best one could with what happened to be at hand in the shortest space of time.

The golden rule in the Army is "do it now." Never mind how or with what, do it. And it is in just such instances that the American engineer on the front was enabled to put over the big jobs by bringing into play his remarkable faculties of ingenuity and resourcefulness coupled with quick action; all of which combined made him a winner and helped to break down the German war machine.

Imagine arriving at a section of the front new to you and your men and receiving orders that a certain piece of road must be opened at once. The road, surroundings, and materials are all unknown to you. That calls for quick reconnoisance to get a line on the work.

WORK BY THE "TOUCH SYSTEM."

This article will deal primarily with road construction during active operations at the front in mobile warfare, as this was the phase of fighting mostly encountered by the Americans. This will, of course, not be applicable to the conditions of fighting in France which obtained for four years before the Germans were driven from the trenches and compelled to resort to the former style of warfare.

It is rather difficult to draw a mental picture of conditions at the front during the advance of a big drive. Everyone must have impressions from childhood of the day the big circus came to town; everything was bustle, noise, crowds, and seeming confusion. Things at the front were in very much the same shape; the country unfamiliar, the location of units not known, the roads impassable in nearly all instances from either density of traffic or large shell holes and mine craters. The incoming shells and aeroplane bombs only tended to make matters worse and add to the confusion. This was the usual condition under which the road engineer had to work and if it happened to be night on a road you had never seen the task became almost hopeless and about all that could be done was to fill shell holes by the "touch system," for, of course, no lights were allowed.

During such times and under such conditions as those just described road work resolved itself into a question not of building or repairing but simply one of keeping the roads open in any manner possible so that the continuous stream of ambulances, ammunition and supply trucks, artillery, motorcycles and automobiles could pass on uninterruptedly. To this end many expedients were resorted to for obtaining material and repairing the roads.

YAWNING MINE HOLES TO BE FILLED.

The French roads are justly famous. The prevailing type is the water-bound macadam, and in normal times these are kept in a wonderful state of repair by the most painstaking methods of maintenance done under the patrol system. This does not apply in a measure to conditions at the front, for there it was not possible to give the roads such attention, and the constant heavy traffic played havoc with them. Through "no-man's land" the roads have been practically obliterated by constant shell fire and mines, and it was there that the engineers had their hardest work. It was, of course, quite necessary that the roads across this stretch be opened up at once.

Almost without exception the main roads across "no-man's land" had been mined by the Germans, and upon their retreat the mines were set off, blowing the road off the map and leaving gaping holes 30 to 50 feet deep and with a diameter of about 100 feet. In such a case the only thing to do was to construct an entirely new road around the crater until things had quieted down a bit, and then go back and either fill the hole or bridge it. Then, upon getting back to the old road, the chief trouble would be with shell holes in the road. These varied all the way from 2 feet to 20 feet deep and a diameter of 3 to 30 feet. This called for quick filling methods, with any hard material at hand, and right here was where one of the greatest difficulties arose: that of getting proper materials for filling these numerous holes. If one were lucky enough to have a few trucks bringing up rock from the rear, things would run along smoothly enough, but this was more often the exception than the rule.

GERMAN SHELLS FURNISH MATERIAL.

The houses in the French villages are almost without exception built of stone with a rather dry mortar. These houses were, for the most part, shot to pieces, so that the stones were available for use in filling these holes along the roads, and the engineers did not hesitate to use this material wherever possible.

The Germans were not sparing with the use of concrete on their trenches, dugouts, and "pill-boxes." These were in many cases torn up to obtain material for road work. When this was resorted to there was nothing left but the steel-rod reinforcement.

There are, in many sections of the Argonne Forest and the adjoining country to the east, a substratum of clay with rocks ranging in size from a man's fist to his head. In sections where the shelling had been heavy, large quantities of these rocks would be blown out of the ground and others left loosened up in the holes. These were used when nothing else could be had. It was no uncommon sight to see men in the fields along the roads collecting these rocks in sand bags, sacks, boxes, and on sheets of corrugated iron, for filling the holes in the roads. Other sources of materials were stone fences along the roads, roofing tile, sand bags filled with earth, etc.

There was one thing that could be found on the front without fail during active operations, and that was rain. Some of the roads through the Forest of Argonne and surrounding country that were of minor importance suddenly became of great importance during a drive, and had to be opened up. These were given the same kind of attention as the other roads except in cases where the soil was a very sticky clay, in which case it usually was necessary to corduroy. The same scouting around for suitable material would occur again, but usually it was found. A company of pioneer engineers has constructed in half a day 75 to 100 yards of corduroy road in addition to scouting around for the material.

WORKED 96 HOURS AT A STRETCH.

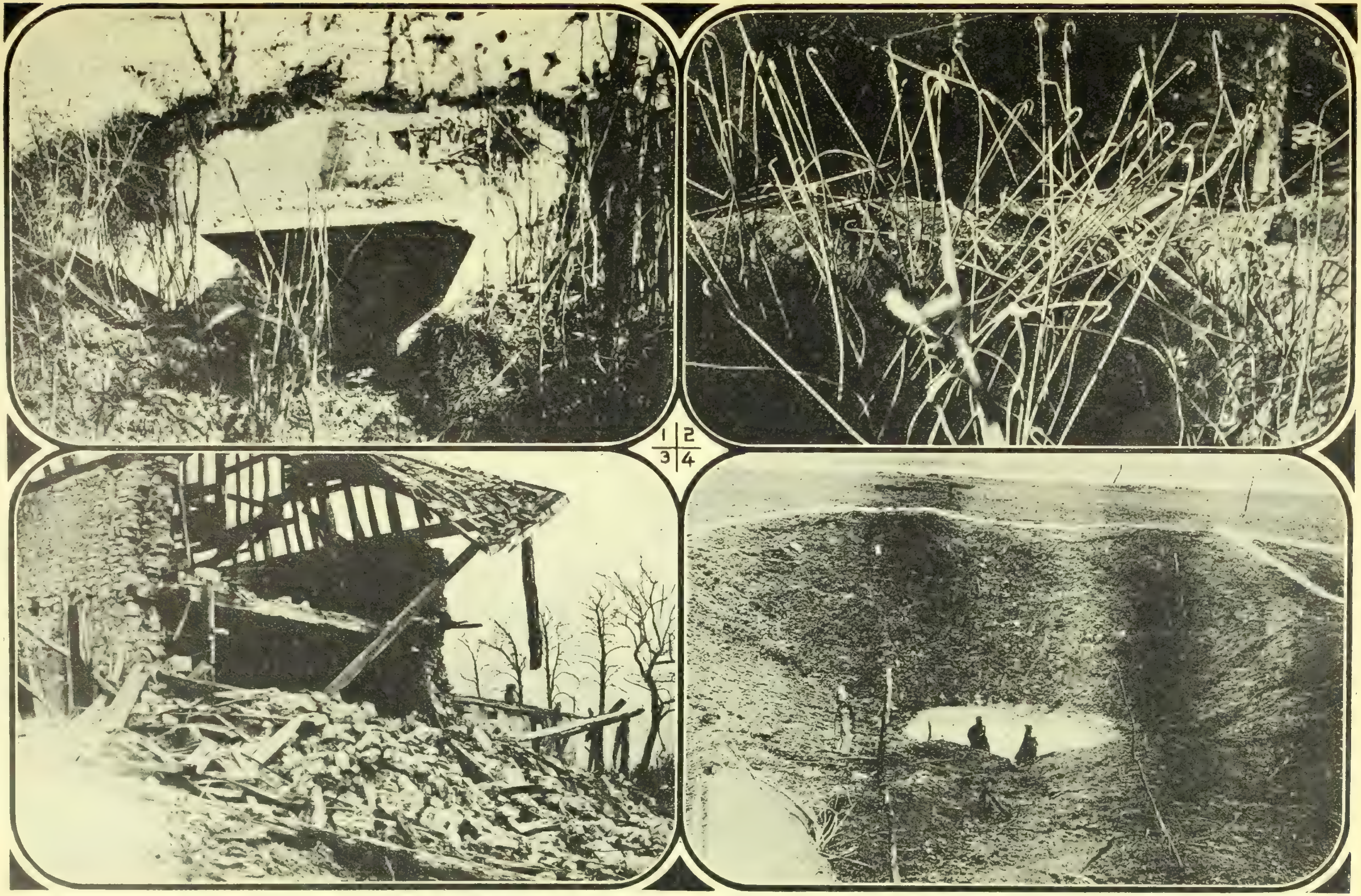
In passing, it might be stated that it was very disheartening to finish up a section of road and then have to go back and do the work all over again as a result of new shell holes. The work had to go on day and night. In some cases it could be done only at night, for where the enemy had direct observations, large bodies of men working on a road were almost certain to draw fire.

This also was one place where the eight-hour law was not strictly enforced. Working day and night for 72 to 96 hours was not an uncommon occurrence, and at the end of such a stretch, the ground or a hard board felt pretty good in lieu of a bed.

All big offensives slowed down after a few days of hard fighting and a lull in operations ensued. This gave the engineers an opportunity to secure some much-needed rest and to do some road work of a little more permanent nature than the rough work just described. Things got on a more normal basis and then the engineers opened up and operated quarries or brought up materials from the rear. There are several of these quarries in the Argonne country with a good quality of limestone which was used quite extensively on the roads in that section. There is also in this section a poor quality of soft-clay rock which outcrops on the hillsides. This was used considerably to fill holes and as a temporary measure did very well. Under constant heavy traffic and wet conditions it would break down and turn to mud in two or three days and it would have to be shoveled out and replaced.

HOW THEY BLEW UP BRIDGES.

The Germans are a very ingenious people, at least so far as the art of war is concerned, and they never



1. GERMAN PILL BOX IN MACHINE GUN POSITION, FOREST OF ARGONNE, BEFORE IT WAS BROKEN UP BY AMERICAN ENGINEERS FOR MATERIALS FOR ROAD CONSTRUCTION, AND, 2. SHOWING STEEL REINFORCEMENT, ALL THAT WAS LEFT. 3. HOUSE SHOWING RESULTS OF GERMAN SHELL FIRE, WHICH ALSO FURNISHED MATERIAL FOR REPAIRING ROADS. 4. ROAD IN THE ARGONNE FOREST AFTER IT WAS HIT BY A GERMAN SHELL.

overlooked anything that hindered the enemy in his advance. To this end the roads were mined and bridges destroyed. One rather novel method of destroying the small bridges consisted in making a girdle of from 12 to 15 hand grenades around each pile, under the bridge, putting a cap in one of them and connecting them up to a battery. Upon firing, the pile would be cut off and down came the bridge. The hand grenades used for this purpose were those with the handle for throwing, called by the American doughboys "potato mashers." This is cited merely to show one instance of where the Boche used his head.

In order to handle the endless stream of traffic at the front, the plan of one-way traffic now in vogue in some of the cities was adopted and proved quite successful. The routes of travel would, of course, have to be worked out hurriedly and many a poor truck driver has had to drive all over the world to get to his destination of a few kilometers, as he would have to follow the route of travel on the one-way roads and that was not always in the direction he wanted to go.

Unless a man was on staff or some special duty which carried him to different parts of the front, the knowledge he gained was confined solely to the immediate vicinity in which he was working. This is true to a remarkable extent. It is surprising what little one knew of what was going on around him during active operations. His vision was quite restricted, and limited only to the immediate part of the front in which he happened to be. As to what was going on in other parts of the line he was utterly oblivious and knew nil. Those in the rear, in the S. O. S., and in the States knew far more concerning the general operations. This makes it rather difficult to generalize, and what has been written is confined to the Forest of Argonne section.

LACK OF TRANSPORTATION.

The Americans in the big Argonne-Meuse offensive of September 26 to November 11, 1918, fought under many great disadvantages. Many of the men had never before been in a battle and things were bound to be confused at times. However, one of the greatest disadvantages was lack of transportation. This tied up certain phases of work very materially at times. A company of pioneer engineers is supposed to have two motorcycle side cars, four bicycles, and the usual quota of wagons, water carts, rolling kitchens, etc., with 41 head of horses and mules. Companies that had 10 horses to pull their equipment were lucky and motor transportation or bicycles were unknown. But in spite of all obstacles and set-backs the Americans had the fighting spirit and the determination to drive the Germans back, and they did it.

GOOD ROADS IN TEXAS.

Highway building in Texas is at its highest tide since impetus was given to it by State and Federal aid. It is estimated by the State highway engineers that more than $20,000,000 worth of roads are now under construction. Bond issues in counties and subdivisions of counties are of weekly occurrence and the agitation for good roads is so general that enthusiasts believe that all the State highways in Texas will soon be built and maintained in a high state of usefulness.

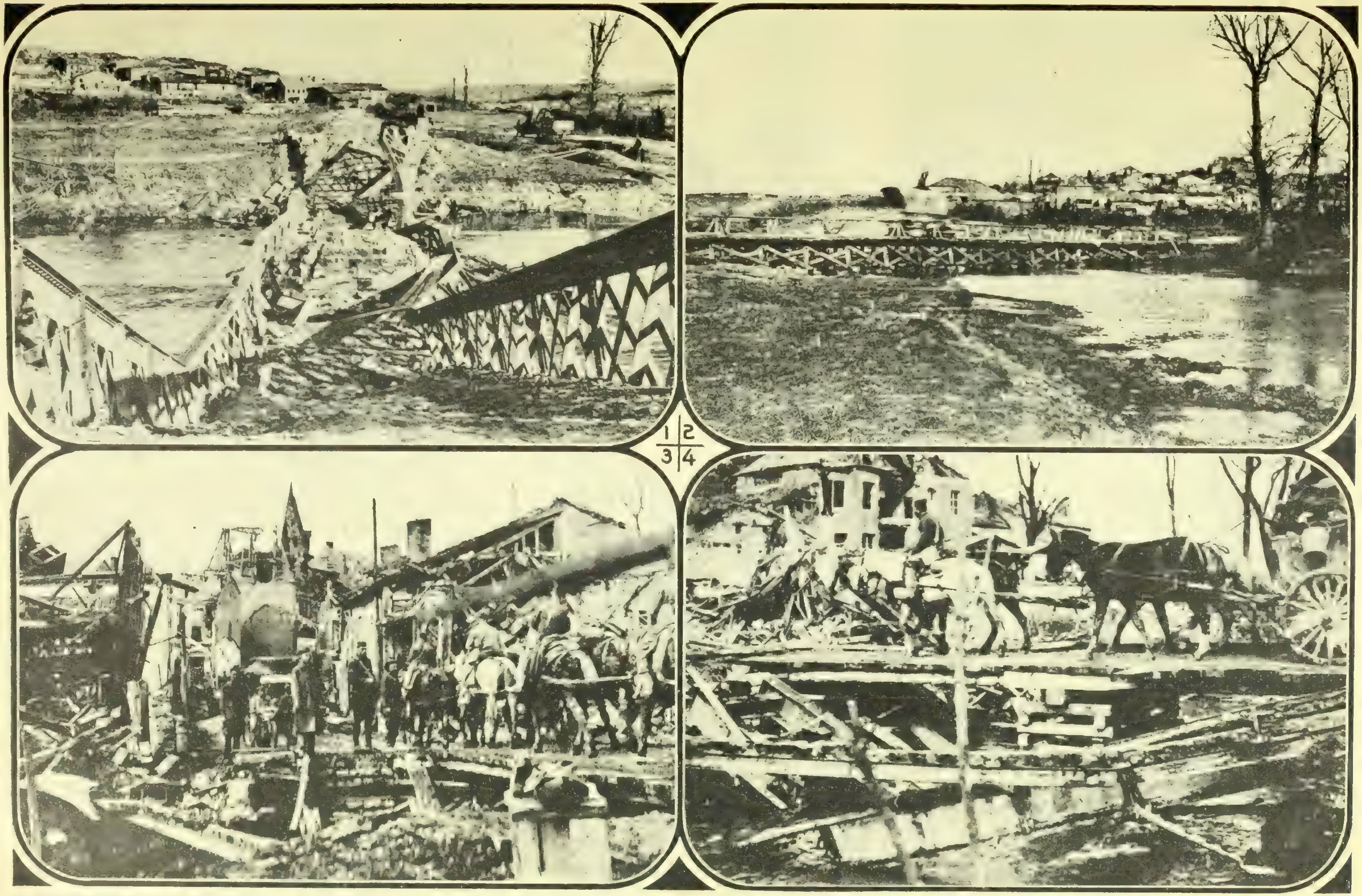
Representative C. O. Laney, the author of the $75,000,000 road bond amendment which the people will vote on next November, estimates that $200,000,000 will be available for road construction in the State during the next 5 years if road bonds contemplated are issued. Counties in the State have already voted or now have pending road bonds amounting to $23,670,000, the State will receive Federal aid money amounting to about $9,000,000 this year with approximately $20,000,000 allotted for the next three years. The voting of the $75,000,000 will greatly stimulate the further issuance of county bonds during the five-year period.

SAVE A CENT A MILE.

The commissioner of highways of Milwaukee County, Wis., estimates from statistics he has compiled that the improved roads of that county save $2,500 a day to the people who use them. The statistics are based on a census of the traffic taken periodically during the last four years. This census is made by selecting 52 points scattered throughout the county, and making seven counts at each point, one for every day of the week. The count is not made on consecutive days, but at various periods from April to November, so as to arrive at average conditions. This census is taken to determine the durability of certain types of pavement, according to the amount of traffic per square yard. It shows that about 25,000 vehicles of all kinds travel the highways each day. Traffic on the road has increased about 42 per cent a year during the four years in which the survey has been made.

ILLINOIS BOND ISSUE VALID.

The Supreme Court of Illinois has decided, in a test suit, that the $60,000,000 road bond issue approved by the voters last November is valid. The suit was a friendly one, brought that a decision from the court might be secured which would remove all doubt as to the validity of the bonds, so there would be nothing in the way of carrying out the program of road building authorized by the vote.



1 SHOWING GERMAN DEMOLITION OF A BRIDGE OVER THE AIRE RIVER, BETWEEN ST. JERVIN AND MARCY. 2. HASTY BRIDGE CONSTRUCTION, SHOWING BRIDGE OVER THE AIRE, IN THE SAME VICINITY, BUILT BY AMERICAN ENGINEERS. 3. REMAINS OF GRANDPRE' AFTER SHELLING. 4. BRIDGE AT GRANDPRE DEMOLISHED BY GERMANS AND HASTY RECONSTRUCTION ABOVE THE RUINS BY AMERICANS.

BONDING NEW CEMENT-MORTAR AND CONCRETE TO OLD IN TESTS

By W. E. ROSENGARTEN, U. S. Highway Engineer, Bureau of Public Roads.

IT FREQUENTLY is necessary in construction and repair work to join fresh concrete to old or to concrete which has partially set. In order to obtain definite data on the relative value of various methods of increasing the bond an extensive series of tests was planned and carried out in the Engineering Research Laboratory of the Bureau of Public Roads. This series included:

I. Tests on the bond strength in tension of a 1:2 mortar in the form of the standard tension briquette.

II. Tests on the bond strength in cross bending of a $1:\frac{2}{3}:1\frac{1}{3}$ concrete in 4 by 4 by 14 inch prisms bonded to concrete slabs.

III. Tests on the bond strength in shear of a $1:\frac{2}{3}:1\frac{1}{3}$ concrete in specimens in the form of 8-inch diameter cylindrical disks, 2 inches high.

IV. Tests on the permeability or water-tightness of the joints formed by various bonding methods. The same specimens were used in this series as in the shear tests.

CONCLUSIONS DRAWN FROM TESTS.

As a result of these tests the following conclusions may be drawn:

Tension.—It may be safely stated that the ability of fresh mortar to adhere to older material decreases rapidly as the old sets up. Where the older material has set for 24 hours before adding the fresh, the bonding strength is but 44 per cent of that of monolithic construction. Further ageing of the old mortar causes a slight decrease in the bonding ability, which at 7 days is 39 per cent of the original, and at 28 days has reduced to 35.5 per cent.

The bond of new concrete to old can, however, be increased by various methods, which include treatment of the old surface, the use of a bonding medium, and care in handling the new concrete.

The old surface can be treated to increase the bond either by roughing with a steel tool or by a treatment of dilute hydrochloric acid (1:10 concentrated acid and water). The acid acts on the cement particles, dissolving them and leaving the clean surfaces of the aggregate. The remaining salts should be washed off thoroughly. Roughing the surface increases the strength of bond 20 per cent, and the acid treatment increases it 13 per cent, except in the case of the tests where the old concrete has aged 7 days, in which case there appears an unexplainable detriment to the bond due to the acid treatment. Combining both roughening and then treating with acid gives but a slightly greater bonding ability than either by itself.

The application of a thin layer of cement butter as a bonding medium has a decided effect in increasing the adhesive strength. An additional 25 per cent in strength is developed by the addition of the cement-butter layer. If the cement-butter layer is allowed to stand one hour prior to adding the fresh mortar, an additional 3 per cent may be added to the strength. The use of a proprietary compound mixed in with the neat cement butter appears to be of little additional value.

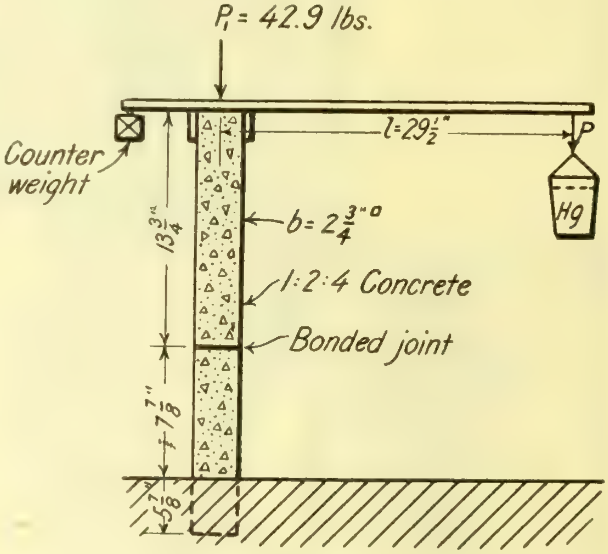


FIG. 1

METHOD USED BY MESNAGER.

The hard tamping of the new mortar against the old, thus forcing it into the pores, has a tendency to increase the strength of bond about 8 per cent.

The broken surface showed a greater bond than either the plain molded or natural surface, as might have been expected. The roughing of the two latter characters of surface had the effect of placing them on a par with the broken surfaces.

The ability to bond to the molded and natural surfaces appeared about equal. A tendency, however, is noted in the case of the surface molded against forms toward a decrease in the strength as the age of old concrete increases, while the natural surface appears to remain fairly constant after the concrete has aged 24 hours.

The effect on the bond of wetting the old mortar surface is hard to determine from the results of these tests. It is at present the usual practice to wet the old work throughly before attempting to bond fresh mortar to it. In about half the above tests this appears to have a detrimental effect, decreasing the bond strength about 10 per cent, while the other half shows it to have increased the bond strength 5 per cent.

The use of a bituminous bonding material is of little value.

The use of sodium silicate appears to have an effect on the bonding strength.

Cross-bonding.—The use of the hydrochloric acid wash on the concrete specimens appears to give a slightly greater bond than does the mechanical roughing of the surface. In the case of the mortar briquettes the opposite was the case.

The old concrete surface wetted develops a bond of only a little over one-fifth the strength of the monolithic concrete, roughing the surface or giving it a hydrochloric acid treatment increases the strength one-sixth and the application of a cement-butter layer adds an additional one-fifth.

The results of this series of tests show the wetting of the concrete to be beneficial. The suggested theory that the cement particles are drawn into the old dry concrete by capillary action, thus increasing the bond, does not appear to be borne out by the tests. This may be due possibly to the fact that in Test II—G, H, and I, page 33—the cement butter had insufficient water, and in Tests II—J, K, and L—where the cement milk was used, there was an excess of water.

The ability of the fresh concrete to adhere to the old decreased rapidly during the early stages of setting of the old concrete, from 100 per cent to about 30 per cent in the first 24 hours. After the old concrete has taken its final set the decrease with the age is very slight.

In general, it appears that (*a*) by careful treatment new concrete can be made to adhere to old with a strength equal to 60 per cent of monolithic concrete. If a greater bond than this is desired it will be necessary to resort to dowels drilled into the old concrete.

(*b*) If no special treatment is given the old concrete other than cleaning off foreign substances before adding the fresh concrete, a bond of but 20 per cent of the monolithic concrete is developed.

(*c*) The surface of the old concrete can be roughened or treated with a 1:10 dilute solution of hydrochloric acid which will increase the bond by 20 per cent of the strength of the monolithic concrete.

(*d*) A bonding medium of a thin layer of neat cement butter spread over the surface of the old concrete will increase the bond 20 per cent of the strength of the monolithic concrete.

(*e*) Tamping the fresh concrete hard against the old concrete, forcing the cement into the pores, increases the bond 5 per cent of the strength of the monolithic concrete.

It must be remembered that the above conclusions refer to a rich concrete—namely, 1:2/3:1–1/3, and that for leaner mixes the percentages very likely would be increased.

Shear.—The shearing strength of a joint is greatly increased by a treatment of the surface of the old concrete, and although it may slightly increase the cost of the work, the added effect would certainly seem desirable.

Permeability.—The results of this series show that there is no danger of leakage at a joint made in concrete of a mixture as rich as 1:2/3:1–1/3, under pressures up to 40 pounds per square inch; when the surface of the old concrete has been treated.

FORMER TESTS NOT NUMEROUS.

Engineering literature indicates that tests on bond were not very numerous. A brief synopsis of several series of tests on bonding new concrete to old, of which records have been found, are included here in order that they may be compared with the results of this investigation.

Since tests on bond strength have not been standardized the results will be comparative rather than absolute. The strengths of bonded specimens are therefore compared with the strength of monolithic specimens in order to obtain a measure of the degree of perfect bond attained by various methods. The strength of the monolithic specimens is considered the limit which may be reached by the various methods of bonding.

TESTS BY M. MESNAGER.

A record of an interesting series of bond tests by M. Mesnager, a Frenchman, was published in 1907. He used specimens of 1:2:4 concrete. The old concrete portion of the specimens was cast in a horizontal position and cured under a damp cloth. After 7 days and 30 days the second half of the specimen was cast on the end of the first half, which was stood in a vertical position, the concrete being well rammed. The connecting surface was left plain just as it came from the forms, with no additional scoring or marking. This surface, on one-half of the specimens, was well wetted before adding the new concrete, while on the remainder the surface was washed with cement grout.

The completed specimens were stored under wet cloths for 28 days and then tested as a cantilever by the method indicated in figure 1. The specimen was firmly set 5¼ inches into a fixed grip. The lower arm and bucket balanced by the counterweight were clamped on the upper end of the specimen and the load applied by pouring mercury into the bucket. Nearly all the specimens first broke some distance above the joint. The loading device was reattached to the remaining portion and again tested until failure occurred at the joint. The tension in the outer fiber was figured from the following formula.

T = tension in outer fiber;
P = weight of mercury;
P^1 = weight of lever arm, bucket and counterbalance = 42.9 pounds;
l = lever arm of P about the specimen;
b = side of section of the specimen = 2¾ inches;

$$T=\frac{Pl\frac{b}{2}}{\frac{b^4}{12}}-\frac{P+P_1}{b^2}=\frac{6Pl}{b^3}-\frac{P+P_1}{b^2}$$

The results of the tests made are shown in the following tables:

AGE OF OLD CONCRETE, 7 DAYS.

	Specimen No.	Tests on each specimen.	"P"—breaking load in pounds.	"T" tension in outer fiber, pounds per square inch.	Remarks.
Plain joint	1	a	3.5	24	Broke ⅞ inch above joint.[1]
		b	3.5	24	Broke at joint.
	2	a	12.2	97	Do.
	3	a	8.7	67	Do.
Average				87	
Grouted joint	4	a	23.4	191	Broke 8 inches above joint.
		b	24.3	198	Broke 4 inches above joint.
		c	25.6	209	Broke at joint.
	5	a	21.9	178	Broke 1¼ inches above joint.
		b	21.6	175	Broke at joint.
	6	a	24.8	202	Broke 1¼ inches above joint.
		b	24.6	200	Broke at joint.
Average				193	

AGE OF OLD CONCRETE, 30 DAYS.

	Specimen No.	Tests on each specimen.	"P"—breaking load in pounds.	"T" tension in outer fiber, pounds per square inch.	Remarks.
Plain joint	7	a	24.5	199	Broke 7½ inches above joint.
		b	24.9	202	Broke 4 inches above joint.
		c	21.2	171	Broke at joint.
	8	a	13.9	111	Broke 10½ inches above joint.
		b	19.1	151	Broke at joint.
	9	a	17.7	142	Do.
Average				163	
Grouted joint	10	a	21.5	174	Broke 11¼ inches above joint.
		b	24.6	200	Broke 9¼ inches above joint.
		c	29.0	234	Broke 2½ inches above joint.
		d	19.7	159	Broke at joint.
	11	a	5.5	91	Broke 8¼ inches above joint.[2]
		b	26.5	216	Broke 1½ inches above joint.
		c	31.6	259	Broke 2 inches above joint.
		d	36.7	302	Broke at joint.
	12	a	24.3	198	Broke 10 inches above joint.
		b	27.8	227	Broke 5½ inches above joint.
		c	26.6	217	Broke 2½ inches above joint.
		d	27.8	227	Broke at joint.
Average				219	

The general conclusions drawn were that a grouted joint is an aid and that hard tamping adds appreciably to the bonding strength, since the new concrete was tamped with much greater force in the case of the 30-day specimens than it was with those in which the old concrete had aged but 7 days.

TESTS BY R. B. PERRY.

Following these tests Raymond B. Perry carried on a similar series of tests as a thesis for a civil engineer's degree at the Case School of Applied Science, which were published in 1908. The specimens were of the same dimensions as those made by M. Mesnager, but were of 1:2 mortar, as it was considered that a more uniform set of specimens could be obtained and that in practice the treated surface usually is one in which a mortar has flushed to the surface. The mortar was put in the forms wet and only tamped sufficiently to get out the air. The old halves of the specimens were all allowed to cure for 14 days, being kept moist. A new half was then bonded to an old half and kept moistened for an additional 21 days before testing. The load was applied in this case by pouring sand instead of mercury into the bucket. All of the cemented specimens broke at the joint. A set of full-length specimens was cast and tested after 21 days. These all broke at the center.

Various methods of increasing the bond were employed and the results in each case equated to the proportional strength of the monolithic specimens. The results of the tests, as reported, are given in the following tables:

Specimen No.	Method of treating joint.	"T" tension in outer fiber, pounds per square inch.	(*a*) Average.	(*b*) Average of 3 nearest tests.	Per cent of (*a*) to full strength.	Per cent of (*b*) to full strength.
A1	Ends roughened with cold chisel—cuts ¼ to ½ inch deep	158	124	125	49	49
A2		123				
A3		87				
A4		124				
A5		128				
B1	End smooth but covered with a cement paste ⅛ inch	119	133	125	53	49
B2		131				
B3		207				
B4		82				
B5		124				
C	End moistened only. All broke in handling.					
D1	End roughened as in A, and covered with cement paste as in B	279	237	229	94	90
D2		211				
D3		237				
D4		225				
D5		227				
E1	End cleaned and solution of Ransomite applied, then washed off. Thin cement grout rubbed in and ¼ inch cement paste	232	191	228	76	90
E2		128				
E3		220				
E4		231				
E5		146				
F1	End cut with groove on neutral axis ⅞ inch wide, ⅞ inch deep, groove straight angles to cross arm	173	133	127	53	50
F2		133				
F3		120				
F4		128				
F5		110				
G1	Full length prism, 27¾ inches, tested after 21 days	255	252	254	100	100
G2		230				
G3		249				
G4		271				
G5		257				

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[1] Disregard No. 1 as faulty joint.

[2] Disregard test 11–a.

The conclusions drawn from the above tests were—

1. The bond existing at a smooth joint is very slight.

2. About one-half the strength of concrete is developed in a joint bonded by—

(*a*) Roughing the surface;

(*b*) Applying layer of cement paste;

(*c*) By cutting a bonding groove.

3. When the joint is both roughened and a cement paste applied, 90 per cent of full strength is developed.

4. A solution like "Ransomite" takes the place of roughing.

TESTS BY E. P. GOODRICH.

Another series of tests on bonding new concrete to old was reported a year later by E. P. Goodrich. The test specimens in this case were the standard cement briquettes. One set of specimens was molded and broken after 24 hours, the halves being used as the old portion to which the fresh mortar was bonded. Another set of briquettes was molded with a thin strip inserted at the small one-inch cross section. The resulting smooth surface was roughened with a sharp steel tool to imitate the roughing done in practice with the pickaxe or blunt chisel. A 1:2 (by weight) cement mortar was used. All the specimens were cured in air to approximate more nearly actual working conditions. The new mortar was added to the old half specimens after they had aged for 24 hours and 7 days. All specimens were broken at the end of 30 days from time of binding. The results of the tests are shown in the table below:

Treatment of old surface before adding fresh mortar.	Broken surface.				Smooth surface roughened.			
	24 hours.		7 days.		24 hours.		7 days.	
Dry	161 [1] H 92	126	$ 285 313 343	314	162 205 80	149	[1] H [1] H 15	15
Soaked 10 minutes in water	[1] H [1] H 60	60	138 218 212	189	165 90 208	154	[1] H [1] H 44	44
Grouted, dipped end in creamy cement.	380 315 [1] H	347	347 280 200	276	98 43 160	100	[1] H [1] H [1] H	
HCl, treated with 1:10 solution HCl and washed clean.	68 [1] H 155	112	126 175 221	174	87 232 105	141	83 51 44	53
"Bondsit" powder, 5 pounds to 10 gallons water used as HCl above (a sulphuric acid).	30 60 4	45	152 105 95	117	79 54 68	67	172 26 114	104
Average		147		207		122		69

Whole briquettes—363, 384, 309, 438, 415, 304, 427.
Average, 377.

[1] H—Denotes break in handling.

The conclusions drawn by Mr. Goodrich were:

(*a*) Since best results were obtained from the natural fracture, it points to a purely mechanical bond or one with little cementitious action.

(*b*) Practically no bond is developed on the surface molded against the form and which had dried for 7 days.

(*c*) Thorough soaking of work is essential. In the 7-day smooth surface, grouted bond, water was absorbed so rapidly from the grout as to render it an actual detriment. However, in 24 hours and 7 days, rough surface, soaked, would lead one to suppose there is a possibility of using too much water. This was thought possible in the laboratory but not in practice. The use of dry cement sprinkled over the old surface dampened is of questionable value.

(*d*) A coat of grout is advantageous, after first having soaked the old concrete thoroughly.

(*e*) The acid treatment when the old concrete has aged but 24 hours is of little value.

(*f*) The acid treatment is advantageous on surfaces molded against forms and having dried for seven days.

(*g*) The acid treatment gives more consistent results than other methods.

(*h*) It is difficult to explain why the rough surface, 7-day specimens were stronger than the 24-hour specimens, unless small particles were loosened and still clung to the damp surface and were brushed off the dry 7-day surface.

TESTS BY J. L. MINER.

J. L. Miner carried out a series of tests at the Lafayette College for the purpose of determining the comparative strength of different joints in bonding new concrete to old. The first half of beams were allowed to set for 48 hours before adding the remaining half. All beams were broken at the end of two months. Three kinds of aggregate and mixes were used.

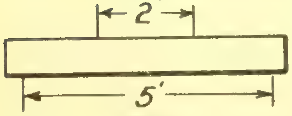
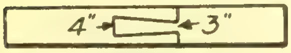
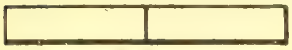
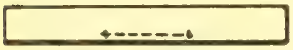
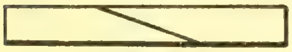
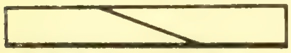
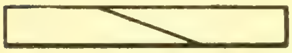
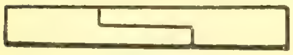
Mix No. 1.—Clean, sharp bank sand $\frac{1}{4}$ inch to dust, and crushed dolomitic limestone passing $1\frac{1}{4}$-inch and retained on $\frac{1}{4}$-inch screen, in the proportion of 1:2:3, using 8 per cent of water and mixed by hand.

Mix No. 2.—Crushed dolomitic limestone screenings under $\frac{1}{4}$ inch, and crushed dolomitic limestone passing $1\frac{1}{2}$-inch and retained on $\frac{1}{4}$-inch screen, in the proportion of $1:1\frac{3}{4}:3\frac{1}{4}$, using 10 per cent of water.

Mix No. 3.—Clean, sharp bank sand, $\frac{1}{4}$-inch to dust, and gravel from pit along the Delaware River above Easton, all passing $2\frac{1}{4}$-inch and retained on $\frac{1}{10}$-inch screen, in the proportion of 1:1:4, using $7\frac{1}{2}$ per cent of water.

The concrete was well rammed with a $\frac{3}{4}$-inch round iron bar with a nut on the end. The loadings were in increments of 200 pounds, and the deflections noted each time. The breaking load was recorded and the modulus of rupture figured. The beams were tested on a 5-foot span with the load applied at two points, one 12 inches each side of the center.

The results of the tests are given in the following table:

		Kind of joint.	Mix No. 1.		Mix No. 2.		Mix No. 3.	
			Pounds.	Average.	Pounds.	Average.	Pounds.	Average.
 SOLID	A	Solid	2,200 3,100 3,400	3,275	1,700 950 1,850	1,775	2,900 3,700 3,000	3,200
 DOVETAIL	B	Dovetail	1,400 1,900 1,800	1,700	1,350 1,350	1,350		
 VERTICAL ROUGHENED	C	Vertical roughened	750 1,050	900				
 VERTICAL REINFORCED	D	Vertical reinforced, two ¾-inch rods 18 inches long with nuts on either end, 1½ inches from bottom, 2 inches from sides					2,900 3,100 3,700	3,233
 SCARF	E	Scarf (⅓ length of beam)	2,150 2,300 2,450	2,300	1,850 1,900 1,750	1,833		
 SCARF-OXALIC ACID WASHED	F	Scarf washed with oxalic acid (⅓ length of beam)			2,150 2,250	2,200	3,900 2,900 3,500	3,433
 SCARF - CEMENT WASHED	G	Scarf washed with cement (⅓ length of beam)					3,200 2,700 3,700	3,200
 STEP	H	Step, 18 inches long			800 550	675		

The conclusions drawn from the tests were that the reinforced was the strongest end the scarf joint next strongest. Scrubbing the old surface with oxalic acid helped to increase strength slightly.

TEST OF H. ST. G. ROBINSON.

A paper by H. St. G. Robinson, Institute of Civil Engineers in London, tells of a series of tests on the adhesion of new concrete to old. Prisms of concrete were tested as cantilevers. Six specimens of each kind of joint were tested. All were cast at the same time and the artificial joint made 7 days later, and the set tested 28 days after their manufacture.

Considering the solid prism as 100 per cent efficient, the various methods of bond showed the following degrees of efficiency:

	Per cent.
(*a*) Face wetted only	38.3
(*b*) Face roughened and wetted	56.2
(*c*) Face roughened and grouted	85.5
(*d*) Face treated with acid, cleaned, and new concrete applied	82.0

PRESENT SERIES OF TESTS.

In the light of the foregoing, the present series of tests was planned and carried out in the concrete research laboratory of the Bureau of Public Roads, to determine the value of various methods of bonding new concrete to old.

SERIES I—TENSION.

The simplest and most direct means of testing the bond of new concrete to old was by use of the standard tensile cement test, specimens having a 1 inch square section at the plane of bonding. A 1:2 mortar of Portland cement and sand was used in order to develop sufficient strength to cause the specimens to break at the joint and not in the mass itself. In actual practice three general types of surfaces of old concrete to which new concrete is to be joined may be encountered. They are, first, a broken surface, second, a molded surface, as against a wood form, and, third, a natural surface, as a

TABLE No. 1.

Series I. Bonding new cement mortar to old.

[Tension tests, standard 1:2 mortar briquettes, age of bonded joint, 28 days.]

	Bonding method.		Broken surface, age of old half of specimen.			Molded surface, age of old half of specimen.			Natural surface, age of old half of specimen.		
	Surface.	Medium.	1 day.	7 days.	28 days.	1 day.	7 days.	28 days.	1 day.	7 days.	28 days.
A	Dry		[1] H [1] H }154 154	247 274 }234 281	238 306 }288 321	278 305 }310 345	182 198 }192 213	[1] H 168 }174 180	191 171 }181	167 173 }208 283	207 218 }227 257
B	Wet		218 257 }256 293	218 266 }270 295	144 246 }216 257	230 227 }236 250	184 181 }199 231	113 114 }116 121	164 189 }202 252	226 222 }243 282	186 188 }192 201
C	Soaked		274 304 }304 333	221 228 }233 249	204 218 }233 278	225 257 }250 279	184 194 }194 203	106 124 }113 128	197 201 }199	204 288 }262 294	143 193 }186 221
D	Wet	$\frac{1}{16}$-inch layer cement butter	402 420 }432 473	399 487 }476 542	382 376 }396 429	290 345 }315 309	237 262 }254 263	155 155 }157 161	230 291 }283 329	317 318 }355 423	193 284 }256 292
E	Wet	$\frac{1}{16}$-inch layer cement butter tamped hard	352 457 }434 493	423 544 }506 551	430 451 }460 500	401 432 }424 438	326 336 }340 358	163 176 }180 210	316 370 }356 384	302 321 }325 353	259 267 }285 330
F	Roughened and wet						261 285 }276 284	217 234 }241 274	257 284 }277 290	236 248 }263 301	207 235 }229 247
G	do	$\frac{1}{16}$-inch layer cement butter				438 445 }451 471	403 480 }455 483	395 417 }427 471	286 391 }424 495	404 429 }420 429	367 399 }398 427
H	do	Sprinkled dry cement	402 399 }411 432	363 434 }410 437	296 401 }371 415	322 364 }359 392	240 346 }310 346		330 347 }344 354	266 335 }315 344	302 326 }338 386
I	HCl washed	$\frac{1}{16}$-inch layer cement butter	398 450 }448 497	214 230 }226 233	398 426 }437 486	394 428 }415 443	174 210 }202 221	333 350 }351 370	351 401 }391 421	385 386 }386 386	313 345 }379 479
K	Wet	$\frac{1}{16}$-inch layer 1:20 by weight proprietary compound and cement butter.	423 450 }459 505	380 453 }434 467	358 421 }407 443	372 401 }391 401	331 352 }346 350	198 336 }298 359	222 288 }289 358	252 307 }310 371	204 240 }239 273
L	Dry	Thin layer bitumen	82 84 } 84 86	66 77 } 81 100	82 90 } 89 95	87 93 } 89 99	68 68 } 74 87			71 80 } 79 86	74 74 } 77 83
M	Wet	$\frac{1}{16}$-inch layer cement butter stand 1 hour	417 423 }422 426	430 466 }478 538	378 442 }430 472	396 399 }409 431		163 171 }171 180	255 288 }286 314	188 216 }286 264	215 398 }356 454
N	Wet	Soaked with 10 per cent solution of sodium silicate.	216 219 }224 237	219 217 }227 246	238 257 }255 269		208 219 }229 262	107 133 }130 150	145 177 }199 274		141 155 }174 226
P	Dry	Soaked with 10 per cent solution of sodium silicate.		166 203 }197 223				[1]H. 132 }141 151	[1]H. 242 }258 274		
Q	Wet	Thin layer bitumen			90 92 } 92 95						
R	HCl washed		249 266 }264 278			242 251 }258 281			246 267 }264 280		125 166 }174 232

[1] H. break in handling.

TABLE No. 2.

Series I. Bonding new concrete to old.

Tension tests on standard 1:2 mortar briquettes.

Per cent of perfect bond.

[Based on average strength of whole briquette = 570 at 28 days.]

	Bonding method.		Broken surface.			Molded surface.			Natural surface.		
			Age of old mortar at time of bonding.								
	Surface.	Medium.	1 day.	7 days.	28 days.	1 day.	7 days.	28 days.	1 day.	7 days.	28 days.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A	Dry		27.0	41.0	50.5	54.4	33.7	30.5	31.7	36.5	39.8
B	Wet		44.9	47.4	37.9	41.4	34.9	20.3	35.5	42.6	33.7
C	Soaked		53.3	40.9	40.9	43.8	34.0	19.8	34.9	46.0	32.6
D	Wet	$\frac{1}{16}$ inch layer cement butter	75.8	83.5	69.5	55.3	44.5	27.5	49.7	62.0	44.9
E	do	$\frac{1}{16}$ inch layer cement tamped hard	76.2	88.2	80.7	74.4	59.6	31.6	62.5	57.0	50.0
F	Roughened and wet						48.4	42.3	48.6	46.1	40.2
G	do	$\frac{1}{16}$ inch layer cement butter				79.2	79.8	75.0	74.4	73.7	69.8
H	do	Sprinkled dry cement	72.1	71.9	65.1	63.0	54.4		60.4	55.3	59.3
I	HCl washed	$\frac{1}{16}$ inch layer	78.6	39.7	76.7	72.8	35.4	61.6	68.6	67.7	66.5
K	Wet	$\frac{1}{16}$ inch layer 1:20 by weight cement butter.	80.5	76.1	71.5	68.6	60.6	52.3	50.7	54.4	41.9
L	Dry	Thin layer bitumen No. 12032	14.7	14.2	15.6	15.6	13.0			13.9	13.5
M	Wet	$\frac{1}{16}$ inch cement butter, stand 1 hour	74.0	83.8	75.4	71.7		30.0	50.1	39.1	63.4
N	do	Soaked with 10 per cent solution of sodium silicate.	39.3	39.8	44.7		40.2	22.8	34.9		30.5
P	Dry	do		34.5				24.7	45.3		
Q	Wet	Thin layer bitumen No. 12032			16.1						
R	HCl washed		46.3			45.2			46.3		30.5
			57.9	57.1	57.2	61.2	47.6	39.8	51.5	52.8	49.3

smooth glossy upper surface where old concrete work has ended.

The age of the old concrete also has an effect on the extent of the bond developed and therefore fresh mortar was bonded to half briquettes which had aged 1 day, 7 days, and and 28 days.

The broken surface was obtained by molding briquettes in the ordinary manner and breaking them just prior to bonding. The halves were used separately, to which the fresh mortar was bonded. The molded surface was formed by placing thin wet wood partitions across the 1-inch section of the molds. Upon removing the specimens from the molds they parted into halves, presenting a flat surface similar to that formed by the ordinary wooden form boards. The natural surface was obtained by standing the briquette molds on end and closing in the sides of the molds, up to the 1-inch cross section, with pieces of plate glass. The mortar was then tamped into the lower half of the mold and allowed to set up under damp cloths.

When the original half specimens had cured the first 24 hours in damp air and the remainder of the time under water, the surface was treated by the various methods and then placed in one end of the briquette molds and fresh mortar added, tamping in the usual manner, except when otherwise noted. The bonded specimens were stored for 24 hours in damp air and 27 days under water. The water in the storage tank was changed occasionally. All specimens were tested when the age of the bond was 28 days.

BONDING METHODS.

The treatment of the old surface to form the bonding joint was as follows:

Method "A."—The half specimens were allowed to dry in the air of the laboratory for 24 hours, except in the case of the 24-hour tests, which were stored in the damp closet overnight and allowed to dry in the laboratory air about 4 hours before adding the fresh mortar.

Method "B."—The half specimen was removed from the water-storage tank, excess water mopped off and fresh mortar added.

Method "C."—Similar to "B," except excess water was allowed to stand on bonding surface.

Method "D."—The half specimen was treated as in "B" and then a $\frac{1}{16}$-inch layer of cement butter (cement and water mixed to plastic consistency) was spread over the surface of the joint prior to adding the fresh mortar.

Method "E."—Similar to "D" except that the fresh mortar was tamped hard into the remaining half of the mold with the end of a knife handle.

Method "F."—For this set the molded and natural surfaces of the old half specimens were entirely roughened by nicking with the corner of a cold chisel, brushed off clean, and the fresh mortar added.

Method "G."—Similar to "F," except that a $\frac{1}{16}$-inch layer of cement butter was spread before adding fresh mortar.

Method "H."—Similar to "F," except that a thin layer of dry cement was sprinkled over the surface prior to adding the fresh mortar.

Method "I."—The surface of the old half was treated with a dilute solution of hydrochloric acid (1 part concentrated HCl to 10 parts water). This was allowed to set for several minutes, the surface then thoroughly washed and a $\frac{1}{16}$-inch layer of cement butter added before molding the remaining half of the specimen.

Method "K."—The old half specimen was given a $\frac{1}{16}$-inch layer of a proprietary compound, made by mixing the compound, a powder, and cement in the proportion of 1:20, with water. The remaining half of specimen was then molded as in the previous cases.

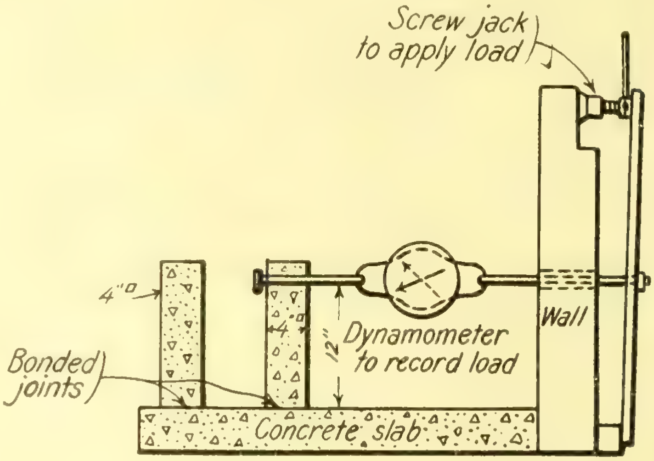


FIG. 2

METHOD OF MAKING BENDING TESTS.

Method "L."—The old surface was dried as in "A" and a thin layer of hot bitumen spread over the joint. The fresh mortar was then applied.

Method "M."—The set was treated similarly to "Method D," except that after spreading the $\frac{1}{16}$-inch cement-butter layer, it was allowed to stand one hour before adding the new mortar.

Method "N."—The old surface was given a thorough soaking with a 10 per cent solution of sodium silicate.

Method "P."—Similar to "N," except that the old half was first allowed to dry as in "A."

Method "Q."—Similar to "L." except that the old half was not dried, but used as it came from the water-storage tanks.

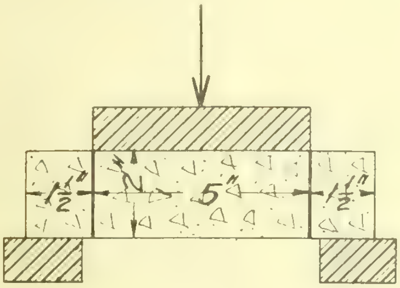
Method "R."—The old surface was treated with a dilute HCl solution, as described under "Method I," and the fresh mortar added. No cement cream was used in this case.

Tables Nos. 1 and 2 on the foregoing page give the results of the tests of this series.

SERIES II—BENDING.

Realizing that the results obtained from mortar tension specimens with but a 1-inch-square breaking area have their limitations when applied to concrete construction, a series of tests were made on columns of concrete 4 by 4 by 14 inches bonded to a concrete slab. The wood forms were removed from the columns after 48 hours. The specimens were kept under a damp cloth for two weeks and in the laboratory air for two weeks. All were tested when the age of the bond was 28 days.

A 1:2/3:1-1/3 mix of Portland cement, sand passing a ¼-inch screen, and gravel retained on a ¼-inch and passing a ½-inch screen were used. The slabs were cast on edge and the surface upon which the columns were set was formed by the sides of wood molds. The roughened surfaces were formed by entirely chipping off the old surface with a cold chisel until the clean stone surfaces were exposed. The hydrochloric-acid treatment was similar to that mentioned on the series of tests on the tensile briquettes. The cement butter, made by mixing cement and water to a plastic consistency, was spread over the surface of the old concrete to a thickness of approximately ⅛ inch.



METHOD OF MAKING SHEAR TEST AT JOINT

The results of the small tensile briquette tests seemed to indicate that there might be a possible advantage in having the old concrete dry before adding the fresh concrete, a rational explanation being that the fine particles of cement are drawn into the pores of the old concrete with the water by capillary action, thus knitting together the old and new. In the tests G, H, and I of Series II, the effectiveness of the ⅛-inch layer of cement cream was impaired by the rapid withdrawal of the moisture into dry concrete. In order to overcome this and at the same time secure the possible advantage of the capillary action in assisting the bond tests, J, K, and L were made, using a wash of cement milk (equal parts by weight of cement and water) on the dry surface of the old concrete, followed by the ⅛-inch layer of cement butter. In order to obtain the effect of the age of the old concrete in its early stages of setting on the bond, the series of tests "M," below, were made. The first column was cast simultaneously with the slab. The next five were cast on the slab at later intervals, as shown in the table.

The tests were made in bending by pulling over the columns, as indicated in figure 2. The load was applied by the slow uniform turning of a screw jack, and was measured by means of a Chatillon dynamometer, having a maximum hand to indicate the breaking load.

The strength of a monolithic column of concrete, under a bending test similar to the above was obtained by casting a column 4 by 4 inches by 4 feet long. The column was held firmly between metal jaws and allowed to project 14 inches. The bending test then was made with a 12-inch lever arm similar to the other tests. The results of these tests are given in the following table:

SERIES II—BONDING NEW CONCRETE TO OLD.

Bending tests on 1:2/3:1-1/3 concrete.

(4 by 4 inch column bonded to slab and tested on 12 inch lever arm, age of bonded joint, 28 days.)

	Bonding method		Age of old concrete.	Breaking load.		Per cent strength of monolithic specimen.
	Surface.	Medium.		Each test.	Average.	
A	Roughened and wet.	⅛-inch layer cement butter.	Approximate 2 months.	250 295 355	300	57.7
B	Wet	do	do	170 275 235	227	43.6
C	HCl washed.	do	do	380 315 275	323	62.1
D	Roughened	do	do	180 175 250	202	38.8
E	Wet	do	do	110 115 120	115	22.1
F	HCl washed.	do	do	210 236 185	210	40.4
G	Roughened dry.	do	do	220 280 215	238	45.7
H	Dry	do	do	[1]H 185 165	175	33.6
I	HCl washed and dry.	do	do	290 235 200	242	46.5
J	Roughened dry.	Cement milk and ⅛-inch layer cement butter.	do	190 230 205	208	40.0
K	Dry	do	do	135 140 H	137	26.5
L	HCl washed dry.	do	do	170 H 175	172	33.1
M	Monolithic		0 hours	460		100.0
M	Wet		1½ hours	370		80.5
M	do		2⅓ hours	375		81.5
M	do		3½ hours	175		37.0
M	do		4⅓ hours	310		67.4
M	do		24 hours	140		30.4
N	do	⅛-inch cement butter	do	130		28.3
O	HCl washed.	do	do	255		55.5
	Specimen	Monolithic		480 585 495	520	100.0

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[1] H indicates a break while removing the forms from the specimen.

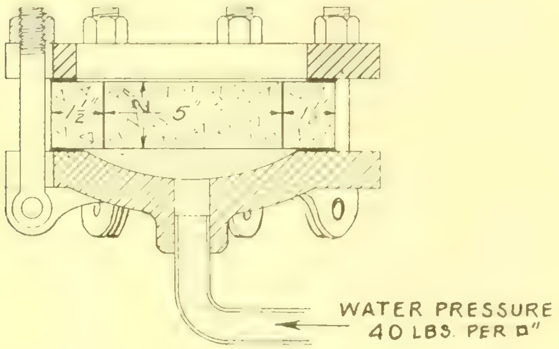
SERIES III—SHEAR.

In practice a joint between old and new concrete may be called upon frequently to withstand a shearing stress. In order to learn the resistance to this character of stress by various methods of bonding, specimens were made and tested for shear. The materials and mix were the same as used in Series II on bending. Concrete rings 2 inches high, having an outside diameter of 8 inches and an inner diameter of approximately 5 inches, were molded; galvanized iron rings were used for the inner and outer forms, making a smooth surface. When these had aged 1 day in damp air and 6 days in water, the inner surface of the ring was treated by the various methods and the center hole filled with concrete. The completed specimens then were stored 1 day in damp air, 3 days under water, and 10 days in air.

A total of eight specimens was made. The treatment of the inner surface of the ring just prior to adding the fresh concrete in the center was as follows: Nos. 1 and 2 were untreated except for thorough wetting. No. 3, the inner surfaces were treated with dilute hydrochloric acid and washed. Nos. 4 and 5 were spread with a one-sixteenth inch layer of cement paste; the surface of Nos. 6 and 7 was first roughened with the corner of a cold chisel until 50 per cent of it was covered with nicks one-sixteenth inch deep, and then washed clean. Specimen No. 8 was a solid disk 8 inches in diameter and 2 inches high.

The specimens were tested by supporting on a metal ring having 6-inch diameter hole. A 5-inch diameter bearing block was placed upon the specimen and the load applied as indicated in the accompanying sketch. The results of the tests are given in the following table:

APPARATUS FOR PERMEABILITY TEST



TESTS ON SHEARING STRENGTH.

Age of joint, 14 days.

Specimen No.	Treatment of bonding surface.	Total load.	Unit shear, pounds per square inch.	Percent strength of solid disk.
1	Plain, wet	8,500	268	29
2		9,600	305	
3	HCl washed	15,770	495	51
4	Plain, $\frac{1}{16}$-inch layer cement butter	17,700	557	59
5		19,040	595	
6	Roughened, wet	22,570	706	74
7		23,830	749	
8	Solid disk	33,440	979	100

It will be seen from the above table that the shearing strength of the 1: 2⅔ 1⅓ concrete used in these tests is close to 1,000 pounds per square inch. Fresh concrete bonded to an old smooth surface develops but 29 per cent of total shearing strength. The treatment of the surface against which fresh concrete is to be placed increased the shearing strength of the joint considerably. The hydrochloric-acid treated surface developed 51 per cent of the shearing strength of the solid disk, the coating of cement cream 59 per cent, and the roughened surface 74 per cent. It is possible that a still greater strength could have been attained had the latter two treatments been combined.

The results of these tests should be conservative, as in all cases the outer ring cracked at the time the center plug of concrete pushed out.

SERIES IV—PERMEABILITY.

In connection with the above tests it was desired to obtain the watertightness of the joints formed by the various methods of bonding. A series of tests was run using the shear specimens after the bonded joints had aged one day in damp air, three days under water, and three days in the air of the laboratory. The concrete disks were clamped in an apparatus shown in the accompanying sketch and a water pressure applied to the under side of the specimen. A water pressure of 40 pounds per square inch was applied with the result shown in the following table:

Age of joint, seven days.

Specimen No.	Treatment of bonding surface.	Water pressure of 40 pounds per square inch.	
		Applied.	Leakage.
		Hours.	*Grams.*
1	Plain wet	1	7.5
2			
3	HCl washed	5	0
4	Plain, $\frac{1}{8}$ inch layer cement butter	5	0
5		3	0
6	Roughened, wet	17	0
7		7	0

Both specimens 1 and 2, in which the joint was untreated except for wetting just previous to adding the fresh concrete, showed slight leakage. Specimen No. 1 showed leakage at 2 points, apparently from small air holes in the ring. The amount of leakage was not weighed, but was slightly in excess of specimen No. 2, which appeared to leak at but one place along the joint. None of the other specimens showed any sign of leakage. The solid disk, specimen No. 8, used in the shear test was not tested for permeability, as the results of the other specimens indicated the watertightness of the class of concrete used.

VIRGINIA ROAD BUILDING.

According to State Highway Commissioner George P. Coleman, of Virginia, road projects to cost $3,105,929 are either under contract or being surveyed in that State. This budget includes road maintenance and reconstruction as well as new highway construction and the work of convicts, and it is more than double any previous annual total for roads in the history of Virginia. It has been financed by Federal, State, county, and private funds, and is exclusive of what counties may spend on roads not embraced in the State or county systems.

In addition to the amount to be expended as outlined, there will be $1,600,000 Federal-aid money available this year, which the State has no fund to meet. The extent to which individual counties can raise funds to meet the requirements under the Federal law has not yet been ascertained.

THE COMMERCIAL SIZES OF CRUSHED STONE AGGREGATES

A Survey of the Present Practice in the States of Ohio, Kentucky, Tennessee, North Carolina, and Georgia

By F. H. JACKSON, Assistant Testing Engineer, and C. W. MITMAN, formerly Aid in Mineral Technology.

THE survey of crushing plant practice inaugurated by the Bureau of Public Roads early in 1917, for the purpose of securing data to be used in the development of a system of standard sizes and uniform nomenclature of crushed stone products, was continued during the past summer in the States of Ohio, Kentucky, Tennessee, North Carolina, and Georgia.

The information secured in the New England and Middle Atlantic States during the 1917 survey was published in the June, 1918, number of PUBLIC ROADS, together with a set of proposed tentative standard sizes based upon an analysis of the data obtained. In the present report the information obtained has been arranged in the same manner as in the article referred to. The deductions made will therefore be comparable.

PLANTS VISITED.

Of the 65 stone crushing plants inspected in the last field season, 34 are located in the western half of the State of Ohio and extend from the edge of Lake Erie southward to the Ohio River. Although stone-crushing plants can be found in almost every county in the western half of Ohio, there are certain centers in which activities are more or less concentrated. These are in the counties of Erie, Sandusky, Lucas, Hancock, Putnam, Allen, Franklin, Clark, Montgomery, and Hamilton. At least two plants were visited in each one of these centers, while in Lucas, Hardin, Montgomery, and Allen counties three plants were visited. The rock quarried throughout the State is a dolomitic limestone, occurring in perfectly horizontal beds varying in thickness from 3 inches to 5 and 6 feet and lying within 6 inches to 2 feet of the surface.

Six plants were visited in Kentucky, four of which are located in the vicinity of Louisville and two in the western part of the State. All of the plants crush limestone of the same character as that found in Ohio.

Five plants were visited in Tennessee. Four of these are located within a radius of 20 miles of Nashville and one located near Chattanooga. The rock crushed is a limestone of good quality when it can be obtained free from bands of shale or "rotten rock" as it is called locally.

Six plants were visited in Georgia, all located within a 50-mile zone of Atlanta. Three of these crushed granite as a by-product to the stone-block industry. Two crushed a bastard limestone and one a granitic gneiss rock. All the plants visited have a small output and (with the exception of one of the plants crushing limestone), make crushed stone almost an incidental industry.

Seven crushing plants were visited in North Carolina, distributed north and south of an imaginary line extending from Asheville to Raleigh. All the plants crush granite rock, two making the crushing industry incidental to the stone block and monumental stone industry.

PROCEDURE.

As pointed out in the article in PUBLIC ROADS referred to above, the most important element in the equipment of a crushing plant, in so far as quality of grading is concerned, is the screen. Screening methods therefore were given first consideration in the study of each plant. The data collected included the length over all, diameter, pitch, and speed of revolution of each screen, the number of screens in operation, and the length and diameter of each section of screen. If gravity or pulsating screens were used, their dimension, pitch, and size of holes in each compartment was obtained; the nominal diameter (or dimensions, if square holes) of each section of the screen at the time of inspection was recorded, together with the total length of each section having the same size holes. In addition, information was obtained pertaining to crushing and elevating machinery such as would present a complete flow sheet of operations.

The general condition and operation of the plant as a whole was noted and recorded. A record was made of each commercial size of crushed stone produced, including the name under which each size is sold, and the limits in size within which each grade is supposed to lie.

Finally, a sample of each commercial grade, available at the time of inspection, was obtained, and a mechanical analysis of each sample was made on the spot. Samples of grades smaller than one-fourth inch were mailed to Washington for mechanical analysis. The size of sample used in making each analysis was based upon the maximum size stone present as recommended by the First Conference of State Testing Engineers and Chemists and given in United States Department of Agriculture Bulletin No. 555.

TABLE I.

Diameter of maximum size stone.	Approximate weight of sample to use.
Inches.	*Pounds.*
0.5	10
1.0	10
1.5	10
2.0	20
2.5	40
3.0	70
3.5	100

SCREENING METHODS IN USE.

All the plants visited are equipped with revolving screens, but a few in Ohio have in addition pulsating screens installed in various stages of the operation. Revolving screens, in the majority of cases, are used to obtain the larger sized products, while the smaller grades are obtained with the pulsating screens. The cost of maintenance of pulsating screens is high and as far as could be determined the only reason for installing them was that, for a limited space, a larger screening area could be obtained as compared with the revolving screen.

In its simplest form the pulsating screen consists of two or three rectangular frames constructed of wood and hung one beneath the other, each frame having a perforated metal or woven-wire screen attached to the under side. The three frames are in turn hung in a frame work and rocked to and fro by means of eccentrics. If a three-tier screen is used the upper has the largest perforations and the lowest the finest. All grades discharge from the screen opposite to the feeding end. These screens may be set either in a horizontal position or may be inclined, combining, in the latter case, the principles of the gravity screen and pulsating screen.

GENERAL RESULTS OBTAINED.

In discussing the results obtained during the last field season the same general order will be followed as in the original report. The tables included have therefore been arranged in the same form, and give relatively the same information as the corresponding tables in the first report.

In Table II the results of the mechanical analyses of the crushed stone products of the plants visited are given, together with those factors in screen design and operation which might presumably influence the actual sizes of the products. An analysis of these results leads, in general, to the same conclusions as were noted last year. Thus, variations in pitch and speed of revolving screens, contrary to the general idea, appear to affect the grading very little. Likewise, it may be noted that, except in a very general way, the dimensions of the screens themselves have little influence on the sizes of the products. This, of course, does not mean that, in any individual case, the diameter, pitch, or speed of the screen does not influence the grading of the material produced. It does seem to indicate, however, that there are other influences at work which overshadow the effect of these variables.

As has been previously pointed out, the rate of feeding the stone into the screen, which, of course, varies continually during the screening operation and therefore can not be recorded, probably influences the grading to a marked degree.

OHIO REQUIREMENTS STANDARD.

In Ohio, practically all the operators are producing stone nominally in accordance with the State requirements for size. These requirements have been standard for some years, and, inasmuch as limestone is quarried throughout the State under practically the same conditions, it would seem that to produce these sizes revolving screens of the same diameter of perforations should be used in the various plants. As a matter of fact, Table I shows that this is far from true. For instance, of the 12 plants in the State producing the Ohio No. 1 standard size limestone (2½–3½ inches or 2½–4 inches), or its equivalent, by means of revolving screens, one plant has 2-inch holes in its screen retaining the product, two plants have 2¼-inch holes, six have 2½-inch holes, two have 2¾-inch holes and one has 3-inch holes. Likewise, in the case of the No. 2 Ohio standard size (2½–1½ inches), in the 11 plants producing this material the same relative variations in size of perforation may be noted.

How these variations in plant installation affect the actual sizes of the product may be gathered from the tabulated mechanical analyses and will be discussed later. Suffice to say that even in a State where standard sizes for broken stone used in road construction have been in use for a number of years, revolving screens with 13 different sizes of holes are used to produce three grades of stone.

SCREENING EFFICIENCY GREATER.

For the purpose of making comparisons between the nominal and actual sizes of product, Table III was prepared. This table is exactly the same in form as Table IV in last year's report. The interpretation of the results obtained therefore may be made in a similar manner.

It is interesting to note that the average efficiency of screening operations is somewhat greater among the plants visited this year than among those in New England and the Middle Atlantic States. As recorded in the original report, 34 per cent of all the plants visited in 1917 produced the ordinary commercial sizes with less than 5 per cent variations from the nominal size of perforations in their retain-

TABLE II.

OHIO.

Plant No.	Type of rock.	Product known as	Pitch, inches per foot.	Speed. R.P.M.	Dimensions.				Sizes of holes.		Mechanical analysis.									Remarks.
					Screen passing product.		Screen retaining product.		Screen passing product.	Screen retaining product.	Per cent over 3 inches.	Per cent between—							Per cent under ¼ inch.	
					Length.	Diameter.	Length.	Diameter.				3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.		
					Feet.		*Feet.*		*In.*	*In.*										
1 M.	Limestone.	3½-inch stone	1½	14	5	42 inches	5	42 inches	4	2	95	5								
3 M.	do	No. 2	1¾	15	4	60 inches	6	60 inches	4	2¾	85	10	5							
5 M.	do	No. 1	1½	18			6	72 inches		2½	40	28	32							
9 M.	do	do	1⅛	15	3	36 inches	10	36 inches	4	2½	52	36	12							
10 M.	do	do	1½	18			8	48 inches		2¾	18	72								
11 M.	do	do	1¼	18	9	48 inches	16	do	4	2½	73	23	4							
12 M.	do	do	1½	18	4	35 inches	4	35 inches	4	2½	34	30	30	6						
13 M.	do	do	30°		10	5 feet wide.	10	5 feet wide.	[1]3½	[1]2½	36	40	24							Inclined shaker screen.
18 M.	do	do	1½	16	16	36 inches	16	48 inches	3¾	2¼	82	13	5							
20 M.	do	do	2	18	6	48 inches wide.	4	do	4	3	47	44	9							Plate set at end of screen to catch rejects.
21-M.	do	do	1½	15	4	72 inches	12	72 inches	3¾	2¾	87	13								
23-M.	do	do	1½	16	4	36 inches	4	36 inches	1½	2¼	75	25								
25-M.	do	3-inch	1	15	6	48 inches	6	48 inches	3½	2½	48	47	5							
26 M.	do	2½-inch	1½	12	4	72 inches	4	72 inches	3	2½	8	86	6							
27 M.	do	Coarse	1¼	15	8	36 inches	4	36 inches	4	1½	31	27	18	8	6					
1-M.	do	1½-inch stone	1½	14	5	42 inches	5	42 inches	2	1¼			1	68	18	10				
2-M.	do	2-inch stone	2	20	4	72 inches	4	72 inches	2¼	1½		7	17	43	28	5				
3-M.	do	No. 3	1¾	15	6	60 inches	16	48 inches	2¾	1¾	3	37	49	5	6					
5-M.	do	No. 2	1½	18	6	72 inches	10	72 inches	2½	2			38	56	6					
6 M.	do	Road stone	1½	12			4	36 inches		1½		4	32	48	16					
7-M.	do	2-inch stone	2	18			3	do		1¾			63	32	5					
9-M.	do	No. 2	1½	15	10	36 inches	8	48 inches	2½	2		6	91	3						
10-M.	do	do	1½	18	8	48 inches	8	do	2¾	1¾		12	47	40	1					
12-M.	do	do	1½	18	4	36 inches	4	36 inches	2½	1¼			47	33	19	1				
13 M.	do	do	30°		10	5 feet wide.	10	5 feet wide.	[1]2½	[1]1½		11	60	29						Inclined shaker, screen.
17 M.	do	Coarse	2	16			10	36 inches		2		28	61	5	6					
18-M.	do	No. 2	1½	16	16	48 inches	5	30 inches wide.	2¼	[1]1¼			36	47	12	5				Shaker screen.
19-M.	do	Coarse	1½	15	4	36 inches	4	33 inches	2½	1¼		57	22	9	9	3				
20-M.	do	No. 2	2	18	12	48 inches	10	36 inches wide.	3	[1]1½		5	34	37	24					
21-M.	do	do	1½	15	12	72 inches	9	84 inches	2¾	1½			36	47	12	5				Do.
23-M.	do	do	1½	16	4	40 inches	4	40 inches	2¼	1½				60	40					
25-M.	do	2-inch stone	1	15	6	48 inches	6	48 inches	2½	1½			36	52	6	6				
26-M.	do	1½-inch stone	1½	12	4	72 inches	8	72 inches	2½	1½		47	28	17	8					
1-M	do	1-inch stone	1½	14	5	42 inches	5	42 inches	1¼	¾					85	10	5			
2-M	do	do	1½	20	16	26 inches	12	48 inches	1⅛	⅞					52	41	7			
3-M.	do	No. 4	1¾	15	16	48 inches	8	do	1¾	1			7	64	29					
5-M.	do	No. 3	1½	18	10	72 inches	10	72 inches	2	1¼				30	61	9				
5-M.	do	No. 4	1½	18	10	do	8	84 inches	1¼	⅞					19	36	42	3		
7-M.	do	1-inch stone	2	18	3	36 inches	6	36 inches	1¾	1				43	39	12	6			
9-M.	do	No. 3	1½	15	8	48 inches	10	48 inches wide.	2	[1]1				46	53	1				Shaker screen.
10-M.	do	do	1½	18	8	do	5	60 inches	1¾	[1]¼				17	52	27	4			
12-M.	do	do	1½	18	4	36 inches	8	36 inches	1¼	¾				12	52	27	9			
13-M.	do	do	30°		10	5 feet wide.	5	5 feet wide.	[1]1½	[1]1				1	49	32	18			Inclined shaker screen.
20-M.	do	do	([2])		10	36 inches wide.	10	36 inches wide.	[1]1½	[1]¼				2	80	16	2			Shaker screen.
21-M.	do	do	1½	16	9	84 inches	12	48 inches	1½	[1]1				2	83	15				
22-M.	do	2½-inch stone	1¾	18	6	36 inches	18	36 inches	2¾	1		8	18	27	34	13				
25-M.	do	1-inch stone	1	15	6	48 inches	6	48 inches	1½	½				2	53	28	17			
26-M.	do	¾-inch stone	1½	12	8	84 inches	4	84 inches	1½	½				1	72	27				
27-M.	do	do	1¼	15	4	36 inches	6	48 inches	1½	½				5	41	25	22	7		
33-M.	do	Flux	1½	16	9	64 inches	8	72 inches	1½	¼					32	48	20			
1-M.	do	½-inch stone	1½	14	5	42 inches	4½	48 inches	¾	¼						5	35	60		
2-M.	do	¾-inch stone	1½	20	12	48 inches	6	3 feet wide.	⅞	[1]⅜					5	30	65			Do.
3-M.	do	No. 5	([2])		6	3 feet wide.	6	do	1	½						62	38			Do.
5-M.	do	do	1½	18	8	84 inches	6	do	⅞	$\frac{3}{16}$						4	21	53	19	Do.
6-M.	do	¾-inch stone	1½	12	4	36 inches	3	48 inches	1	[1]⅜					8	63	24	7		
7-M.	do	½-inch stone	2	18	6	do	4	do	1	⅛						10	35	38	17	
9-M.	do	No. 4	([2])		10	48 inches wide.	10	48 inches wide.	1	½					16	20	34	26	4	Do.
10-M.	do	do	1½	18	5	60 inches	10	60 inches	¾	[1]¼						5	28	63	4	
11-M.	do	do	([2])		12	3 feet wide.	6	3 feet wide.	[1]¾	[1]⅜						11	82	7		Do.
12-M.	do	do	1½	18	4	36 inches	6	2 feet wide.	¼	[1]¼							36	40	24	Gravity screen.
13-M.	do	do	30°		10	5 feet wide.	6	do	[1]1	[1]½						10	47	43		Inclined shaker screen.
15-M.	do	Binder stone	1½	15	15	36 inches	10	48 inches	1	⅜					10	25	25	30	10	
16-M.	do	Screenings	1½	15	4	30 inches	3	42 inches	1	$\frac{3}{16}$						32	47	18	3	
18-M.	do	No. 4	([2])		5	30 inches wide.	15	30 inches wide.	[1]1¼	[1]⅜					54	18	21	7		
20-M.	do	do	([2])		10	3 feet wide.	10	3 feet wide.	[1]¾	[1]¼						33	60	7		
21-M.	do	do	1½	16	12	40 inches	10	48 inches	[1]1	[1]$\frac{5}{16}$					42	27	18	13		
22-M.	do	1-inch stone	1¾	18	12	36 inches	10	do	1	⅜					1	26	47	26		
23-M.	do	No. 3	1½	16	4	40 inches	3	50 inches	1½	½					25	19	24	32		
26-M.	do	½-inch stone	1½	16	8	84 inches	8	84 inches	¾	½						16	76	8		
29-M.	do	No. 4	([2])		16	4 feet wide.	16	4 feet wide.	[1]⅞	[1]$\frac{5}{16}$						6	67	15	12	
30-M.	do	¾-inch stone	1½	15	8	48 inches	7	60 inches	¾	⅜						12	67	18	3	
31-M.	do	Binder	1½	15	8	60 inches	11	48 inches	1	⅜					3	67	30	3		

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[1] Square.

[2] Horizontal shaker.

TABLE II—Continued.

Plant No.	Type of rock.	Product known as	Pitch inches per foot.	Speed, R.P.M.	Dimensions.				Sizes of holes.		Mechanical analysis.									Remarks.
					Screen passing product.		Screen retaining product.		Screen passing product.	Screen retaining product.	Per cent over 3 inches.	Per cent between—							Per cent under ¼ inch.	
					Length.	Diameter.	Length.	Diameter.				3-2½ inches.	2½-2 inches.	2-1½ inches.	1½-1 inch.	1-¾ inch.	¾-½ inch.	½-¼ inch.		
					Feet.		*Feet.*		*In.*	*In.*										
KENTUCKY.																				
35-M.	Limestone.	Coarse stone....	1	18			5	36 inches		2½	67	33								
36-M.	.....do.....	.....do......	1	15	2	36 inches	12	...do...	2½	1	21	49	14	13	3					
37-M.	.....do....	2½-inch stone...	1¼	15	5	...do....	5	...do....	2½	1½	6	39	27	23	5					
40-M.	.....do.....	Ballast......	1½	18	8	40 inches	20	...do....	2½	¼		7	24	28	27	8	6			
35-M.	.....do.....	Binder.....	1	18	6	36 inches	5	...do....	1½	⅜					54	29	17			
36-M.	.....do.....	.....do.....	1¼	18	12	do....	6½	48 inches	1	⅜				12	36	42	6	4		
37-M.	.....do.....	1½-inch stone...	1¼	15	5	...do.....	5	36 inches	1¼	¼				2	52	37	9			
38-M.	.....do.....	Binder.........	1¼	16	12	...do.....	8	48 inches	1½	¼				2	47	45	6			
38-M.	.....do.....	Chips..........	1¼	16	8	48 inches	(1)	(1)	¾	¼							35	58	7	
40-M.	.....do....	Concrete stone..	1½	18	8	40 inches	7	52 inches	1	½						33	18	15	4	
TENNESSEE.																				
42-M.	Limestone.	Ballast......	1½	16	8	48 inches	4	48 inches	3	1½		7	61	25	7					
43-M.	.....do.....	.....do......	1¼	16	4	40 inches	4	40 inches	3	2½	2	87	11							
44-M.	.....do.....	.....do.........	1	16	4	36 inches	4	36 inches	3¼	⅜	18	21	16	12	9	6	7	8	3	
45-M.	.....do.....	4-inch stone......	1¼	16			4	48 inches		2½	62	34	4							
43-M.	.....do.....	Concrete stone.	1¼	16	4	40 inches	4	40 inches	2½	¾			26	21	32	18	3			
45-M.	.....do.....	2½-inch stone...	1¼	16	4	48 inches	6	48 inches	2½	1¼		2	25	45	28					
45-M.	.....do....	1¼-inch stone...	1¼	16	6	...do.....	6	do.....	1¼	⅜					70	23	7			
42-M.	.....do....	No. 3......	1¼	16	8	...do.....	7	60 inches	¾	¼						11	32	18	9	
45-M.	.....do.....	3-inch stone..	1¼	16	6	...do....	5	...do.....	⅝	⅛							20	64	16	
GEORGIA.																				
49-M.	Limestone.	3-inch stone.....	1¼	18	5	48 inches	5	48 inches	3	1½		15	53	25	7					
50-M.	do..	2½-inch stone...	1	21	10	60 inches	5	60 inches	2½	1¼		4	22	65	9					
47-M.	Granite....	1½-inch stone....	1½	15	4	48 inches	4	48 inches	2	1¼			6	72	22					
48-M.	do.	.do......	1¼	16	4	40 inches	8	40 inches	2	¼				25	55	16	4			
52-M.	Gneiss.	2-inch stone	1¼	18	6	48 inches	4½	48 inches	2	¼			6	26	21	39	8			
49-M.	Limestone.	1¼-inch stone	1¼	18	5	...do.....	5	...do.....	1½	¼					15	33	22			
47-M.	Granite..	¾-inch stone......	1¼	15	4	...do.....	4	...do.....	1¼	¼				13	58	22	7			
50-M.	Limestone.	1¼-inch stone.	1	21	10	60 inches	4	72 inches	1¼	⅜				1	31	41	12	15		
47-M.	Granite...	Screenings.	1½	15	4	48 inches	5	60 inches	¾	⅜					2	11	63	23		
48-M.	...do..	¾-inch stone......	1¼	16	8	40 inches	6	48 inches	¾	⅜						5	37	58		
49-M.	Limestone.	..do....	1¼	18	5	48 inches	4	do.....	¾	⅜						7	22	50	21	
52-M.	Gneiss..	.....do........	1½	18	4½	...do.....	4	60 inches	¾	¼						11	47	32	10	
50-M.	Limestone.	⅝-inch stone......	1	21	4	72 inches	(1)	(1)	⅝	No. 10							3	30	67	
NORTH CAROLINA.																				
58-M.	Granite....	2½-inch stone.....	1½	16	4	48 inches	4	48 inches	3	2½		23	66	11						
58-M.	..do...	2-inch stone........	1½	16	4	...do....	4	...do.....	2½	2		2	40	50	8					
57-M.	Trap.....	2½-inch stone....	1¼	16	3	36 inches	3	36 inches	2½	1½			27	63	10					
54-M.	Granite..	2-inch stone........	1¼	18	5	40 inches	5	40 inches	2¼	1¼			64	36						
60-M.	...do..	do.........	1¼	16	8	...do.....	8	.do.....	2½	1¼			28	58	14					
61-M.	.....do.	.do....	1¼	14	9	60 inches	18	60 inches	2½	1¼			20	49	29	2				
56-M.	Aplitic granite.	..do....	1¼	16	8	40 inches	8	40 inches	2½	1			12	29	41	18				
55-M.	Granite..	...do....	1¼	16	5	36 inches	5	36 inches	2½	¼			22	37	18	20	3			
59-M.	.....do..	.do....	1¼	16	3	48 inches	4	48 inches	2	1¼			29	60	11					
58-M.	....do...	1½-inch stone	1½	16	4	...do.....	4	...do.....	2	1¼				31	63	6				
54-M.	....do.....	...do...............	1½	18	5	40 inches	6	40 inches	1¼	1¼			2	56	37	3				
57-M.	Trap....	....do........	1½	16	3	36 inches	3	36 inches	1½	1				19	47	31	3			
58-M.	Granite....	1-inch stone	1¼	16	4	48 inches	(1)	(1)	1¼	¼					10	42	48			
60-M.	.....do	do....	1¼	16	8	40 inches	3	48 inches	1¼	¼					53	34	10	3		
61-M.	.....do...	.....do.............	1¼	14	18	60 inches	6	72 inches	1¼	⅜					24	29	23	20	6	
59-M.	.....do...	...do..............	1¼	16	4	48 inches	4	60 inches	1¼	⅜				5	53	23	12	7		
54-M.	.....do...	..do....	1½	18	6	40 inches	5	48 inches	1¼	¼					49	39	12			
57-M.	Trap.....	...do.......	1¼	16	3	36 inches	3	36 inches	1	¼					14	73	6	7		
56-M.	Granite..	..do...	1¼	16	8	40 inches	(1)	(1)	1	¼					2	8	39	45	6	
54-M.	.....do.....	¾-inch stone....	1¼	18	5	48 inches	4	60 inches	¾	¼						13	32	47	8	
57-M.	Trap	.....do............	1¼	16	3	36 inches	2	48 inches	¾	¼						11	47	33	9	
58-M.	Granite..	.do....	1¼	16	5	48 inches	4	60 inches	¾	¼						2	32	62	4	
55-M.	.....do.....	.do....	1¼	16	5	36 inches	4	48 inches	¾	⅛						12	42	21	25	

[1] Gravity.

ing screens. Table III shows that 37 per cent of the plants visited in 1918 produced stone within this limit of variation. Again, whereas approximately one-half of all the plants inspected in 1917 showed less than 10 per cent variation from the nominal sizes, 62 per cent of the operations studied in 1918 were equally as efficient. This latter average is is raised considerably by reason of the very efficient grading observed in the States of North Carolina and Georgia. The average results for the State of Ohio are practically the same as were obtained during 1917.

Reference to Table II will show in a few instances samples which contained a certain amount of stone larger than the perforations of the plant screen through which the stone was supposed to pass. The reasons for these discrepancies are the same as brought out in the previous article, namely, faulty chute construction, overflowing bins, etc.

SPECIFICATIONS PURELY THEORETICAL.

As explained in last year's report, the reason for analyzing the data obtained in this manner is to secure figures based on actual screening operations, which might be used in framing practical specifications for stone sizes. The average specification covering the size of crushed stone products is purely theoretical. It usually requires stone graded between certain fixed limits without any allowance for imperfect screening. It is the custom, therefore, of most operators to use screens with openings slightly larger than those specified, so as to obtain approximately the sizes desired. This custom results in the production of more or less indefinitely graded products, which sometimes do, but much more frequently do not, meet the letter of the specification. A study of the results given in Table I will show to what extent this is true.

It was in order that operators might be able to use screens with perforations the sizes specified and still secure, with reasonable care, products which conform to definite specification requirements that the system of tolerances given in the June, 1918, number of Public Roads was suggested. This system calls, in general, for products graded between certain fixed limits as determined by laboratory screens, but allows as much as 5 per cent to be retained on the larger screen, and as much as 15 per cent to pass the smaller screen. It also provides, in general, that not less than 25 per cent nor more than 75 per cent shall be retained on a screen with perforations of as nearly as possible an exact intermediate size.

TOLERANCES SHOULD NOT BE REDUCED.

It was felt that for most types of construction in which broken stone is used, products meeting this specification would be satisfactory. They would, moreover, be literally meeting the specification and at the same time would possess the advantage of being practical from the standpoint of the operator. This system of specifying has been used in New York State for a number of years. The only other scheme which has been proposed to care for the situation is the one in use by the State of Pennsylvania. In the specifications of this State, revolving plant screens are used as the basis for determining the sizes required. The results of using this method, insofar as the actual grading of the products obtained is concerned, has been previously discussed.

The information obtained during the 1918 survey would indicate that, from the standpoint of present efficiency in production, the tolerances suggested ast year may not be reduced without eliminating the products of a considerable proportion of the plants involved. Before considering a more rigid specification, it is therefore necessary to presuppose increased efficiency in operation. Whether the increased cost involved in increasing efficiency would be justified is a question. In the opinion of the writers it could only be justified in cases where exceptionally well-graded stone is required.

UNIFORMITY IN NOMENCLATURE.

Referring again to Table II, it will be noted that, with the exception of the State of Ohio, there is practically no uniformity in the nomenclature used in designating crushed-stone products. The State of Ohio has, for some years, used a standard system of stone sizes, each size being designated by a number. The majority of the crushing plants in Ohio which were visited use the State system of numbers in designating their product. This is about as far, however, as the uniformity extends, because even the operators who use the same nomenclature do not always use the same screens for obtaining nominally the same product, nor do the products themselves have always the same grading. This latter point is brought out in Table IV, in which the actual sizes of crushed-stone products sold by plants using the State nomenclature are compared.

That portion of the mechanical analysis included between the vertical lines in each subdivision gives the proportion of the total product which meets the State requirements for size. Some extremely wide variations from the State requirements are shown. The general tendency is to produce larger stone than that specified. This table shows that just 3 out of the 35 products indicated meet the State requirements for size as called for by the number under which each is sold. In the writers' opinion, this table furnishes about as convincing an argument against the practice of specifying definite limits for stone sizes as could be desired.

One point in connection with the standardization of stone sizes which has not been discussed is the effect of character of stone on the maximum size allowable in various types of construction. It is recognized, for instance, that the sizes should be somewhat larger in the case of limestone than where granite or trap is used. It may be necessary, therefore, to modify the proposed system of sizes to cover this point.

GENERAL CONCLUSIONS AND SUGGESTIONS.

As a result of the field investigations carried on during the past summer it is possible to indorse the eight conclusions summarized in the article appearing in the June, 1918, number of Public Roads. It is felt that the necessity for standardizing stone sizes has been demonstrated. It is recognized by both producer and consumer alike, and in the writer's opinion it should be possible very soon to reach some basis of understanding along the lines indicated which will result in the general adoption of a series of standard sizes to be used throughout the country. Numerous operators in the course of these investigations have stated that if a standard system of sizes were adopted they would be able to turn out a better grade of product than is now possible.

The ideal crushing and screening plant operation is one in which the crusher is always crushing stone, the elevator is always elevating stone, and the screen is always receiving and screening a fixed quantity of stone. It is of course practically impossible to keep the crusher operating continuously, so that there are always intermittent periods when the screen is running practically empty. At other periods it is heavily loaded, and between the two extremes the amount of stone in the screen is constantly fluctuating. This is undoubtedly one of the principal reasons for variations in the grading of the screened products. To remedy this condition, it might be found advantageous to install a hopper at the charging end of the screen from which stone could be fed at a definite rate into the screen. Knowing the rate of feed of stone from the hopper to the screen, the speed and pitch of the latter can be adjusted so as to insure the very best possible grading. The size of the hopper need not be larger than is necessary to secure a constant supply of stone from the screen, even should the crusher run idle for a few moments. The elevator would of course discharge stone directly into the hopper instead of into the screen.

NEW JERSEY'S 1920 PROGRAM.

State Highway Commissioner Thompson, of New Jersey, has submitted to the State commission a tentative construction plan for 1920. It proposes the building of 61 miles of State highways, at an estimated cost of $4,107,688, with $150,000 additional for rights of way. The construction work planned for the present season, including both the 1918 and the 1919 programs, amounts to 100 miles. Commissioner Thompson regards the estimates as conservative, and that they probably exceed considerably the actual cost of construction, as they make no allowance for decreased cost of labor and materials.

The commissioner estimated that on March 31 the net available assets at the command of the highway department were $10,493,366, from which amounts, for administration, outstanding contracts, the estimated cost of the 1919 program, and other expenses, aggregates $5,894,263. This will leave $4,599,104 for the 1920 construction.

FROM AUTOMOBILE LICENSES.

The fees for automobile licenses will materially increase the road funds in Massachusetts this year. The commissioner in charge of licenses estimates that the year's receipts will amount to about $2,500,000. All the fund above the expenses of the department will be available for highway work.

TABLE III.

Efficiency of plant screening.

State.	Number of plants.	Approximate size of product.	Proportion of plants showing the following variations from nominal size.			
			Less than 5 per cent.	Less than 10 per cent.	Less than 15 per cent.	Over 15 per cent.
Ohio	15	4 to 2½ inches	34	68	74	26
	19	2½ to 1½ inches	16	42	63	37
	16	1½ to ¾ inch	31	50	63	37
	22	¾ to ¼ inch	50	68	73	27
	72	Average	33	57	68	32
Georgia	3	2 to 1½ inches	67	100	100	......
	4	1½ to ¾ inch	25	75	75	25
	6	¾ to ¼ inch	67	67	67	33
	13	Average	54	77	77	23
North Carolina	7	2½ to 1½ inches	43	57	79	21
	7	1½ to ¾ inch	43	71	100	0
	4	¾ to ¼ inch	25	100	100	0
	18	Average	39	72	92	8
	103	General average	37	62	73	27

TABLE IV.

Plant No.	Known as—	Mechanical analysis.								
		Per cent over 3 inches.	Per cent between 3 and 2½ inches.	2½ and 2 inches.	2 and 1½ inches.	1½ and 1 inch.	1 and ¾ inch.	¾ and ½ inch.	½ and ¼ inch.	Per cent under ¼ inch.
5		40	28	32						
9		52	36	12						
10		18	82							
11		73	23	4						
12	1	31	30	30	6					
13		36	40	24						
18		82	13	5						
20		47	44	9						
21		87	13							
23		75	25							
5				38	56	6				
9			6	91	3					
10			12	47	40	1				
12				47	33	19	1			
13	2		11	60	29					
18				36	47	12	5			
20			5	34	37	24				
21			36	47	12	5				
23					60	40				
5					30	61	9			
9					46	53	1			
10					17	52	27	4		
12	3				12	52	27	9		
13					1	49	32	18		
20					2	80	16	2		
21					2	83	15			
9						16	20	34	26	4
10							5	28	63	4
11							11	82	7	
12	4							36	40	24
13							10	47	43	
18						54	18	21	7	
20							33	60	7	
21						12	27	18	13	
23							6	67	15	12

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He erects a bulwark against sickness or adversity.
He builds a bridge to the better job.
He takes in hand a tool to grasp opportunity.
He sets up a ladder to climb in the world.
He gains control over money and things.
He trains himself for growing responsibility.
He Buys War Savings Stamps.

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REPORTS

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

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U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 15 WASHINGTON, D. C. JULY, 1919

ON THE ROAD BETWEEN TEMPE AND ROOSEVELT DAM APACHE TRAIL

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1919

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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STATE HIGHWAY MILEAGES AND EXPENDITURES IN THE YEAR 1918

By ANDREW P. ANDERSON, Highway Engineer.

BASED on complete reports from 44 of the States, cash expenditures on the rural roads and bridges of the United States for the calendar year 1918 amounted to $286,098,193. To this should be added the value of statute and convict labor, which can not be fixed with any great degree of accuracy but probably amounted to not less than $14,000,000, thus making the grand total expenditures for the year $300,000,000. This total is made up of the actual expenditures for such items as labor, materials, supervision and administration directly connected with the construction, improvement, and upkeep of our public roads and bridges outside the limits of incorporated towns and cities, and does not include any item for sinking fund payments or redemption and interest on road and bridge bonds.

The year 1918 offered an unprecedented condition in practically all lines of highway work. There was not only a tremendous increase and expansion in the amount of heavy truck traffic on our public roads and an unprecedented shortage in regard to road materials, labor, and ready funds, but also a decided increase in maintenance work, which was, however, partially offset by a decrease in the amount of new construction.

COST OF MAINTENANCE INCREASED.

The most striking single development through the year was the tremendous increase in motor truck traffic. Five years ago heavy motor trucks were few in number and limited practically entirely to the paved streets of our larger cities. These vehicles now comprise probably 4 to 5 per cent of the grand total of all our motor vehicles and are to be found wherever traffic conditions permit of their profitable use. But very few of our present roads were designed to carry any large volume of this class of traffic. Consequently, the cost of adequate maintenance was increased greatly during the year. In many places the damage due to the incessant pounding of these fast and heavy vehicles was so great as to require complete reconstruction.

The undertaking of new construction work was of necessity deferred to a large extent during 1918. However, in spite of a sadly reduced and broken organization due to the demands of the war, there continued throughout the year among the several State highway departments a decided forward looking movement to the time when hostilities should be ended. This movement consisted largely in formulating definite plans for the renewal of all lines of activities on an increased scale at the earliest possible moment. Thus, Illinois and Pennsylvania each voted bond issues providing for the construction of a comprehensive system of State roads with the understanding, however, that none of the money should be expended until after the war had closed.

VAST SUMS FOR ROADS.

The full effect of this movement, however, did not become apparent until the early part of 1919, when state and county governments began to make provision for road funds to an extent entirely unknown before. Thus, between November 1, 1918, and July 1, 1919, state highway bonds were voted as follows: Illinois, $60,000,000; Pennsylvania, $50,000,000; Michigan, $50,000,000; California, $40,000,000; Oregon, $12,500,000; South Dakota, $4,500,000; Utah, $4,000,000; Wyoming, $2,800,000; Nevada, $1,000,000; or a total of $224,800,000. Other States have made definite provisions for submitting to a vote of the electors between June 30, 1919, and December 31, 1920, bond issues as follows: Minnesota, $75,000,000; Texas, $75,000,000; Missouri, $60,000,000; West Virginia, $40,000,000; Washington, $30,000,000; Montana, $15,000,000; Maine, $10,000,000; Colorado, $5,000,000; Idaho, $2,000,000; and New Mexico, $2,000,000, or a total of $314,000,000. Alabama, Georgia, and Virginia are each contemplating making provisions for submitting the question of issuing state highway bonds to the voters.

On May 6, 1919, the electors in Oklahoma defeated a state road bond issue providing for $50,000,000. In New York the question of submitting to the voters a provision for issuing $20,000,000 in road bonds was vetoed by the governor, as was also a provision for authorizing $20,000,000 in the State of Arizona.

INCREASE IN FEDERAL AID.

The Federal Government also made provision for a considerable increase in the amount of funds available under the Federal aid road act of July 11, 1916, for the improvement of rural post roads and forest roads. The Post Office appropriation act approved February 28, 1919, carried an amendment to the above act which provided for an additional appropriation of $209,000,000 for Federal cooperation in the improvement of rural post roads and forest roads to be available during the years 1919, 1920, and 1921.

Definite data are not available as to the amount of county, town, district, and other forms of local road bonds which have been voted during the period covered by this investigation. There is, however, abundant evidence that this total far exceeds that already voted by the several States. Many of the State Governments, as well as local communities, have also made provisions for considerable increase in their regular road and bridge revenues or have discovered new sources of such revenues. A large number of the States have materially increased the direct road taxes as well as the registration fees of motor vehicles. Three States—Colorado, New Mexico, and Oregon—have also placed a tax on the sale of gasoline, the income from which is to be used for road purposes.

TERM OF ROAD BONDS.

In a few of our States the question of limiting the term of road and bridge bonds to the probable life of the improvement for which they are issued has as yet received but scant attention. The practice of issuing 30 or 40 or even 50 year bonds to pay for an improvement which can not possibly last more than one-half and probably not more than one-third or one-fourth of this period is neither good finance nor good common sense. In no case should the term of these bonds exceed the most probable life or productive period of the improvement.

Another practice which has served to cover up this evil is that of taking up road bonds on or before their maturity by means of so-called funding or refunding bonds, which almost invariably have a long term. In this way not only is the term of the debt continued for a very much longer period, but it is placed in such form as to cover or conceal its relation to the

TABLE I. EXPENDITURES DURING THE YEAR 1918, BY OR UNDER THE SUPERVISION OF THE STATE HIGHWAY DEPARTMENT.

State.	Funds.				Distribution of expenditure.						State funds available, 1919 (approximate).	Local road and bridge expenditures, 1918, not under State highway department (approximate).
	Federal.	State.	Local.	Total.	Construction. Roads.	Construction. Bridges.	Maintenance, roads and bridges.	Engineering.	Administration.	Equipment and miscellaneous.		
Alabama	$133,380.90	$103,285.32	$134,547.20	$371,213.42	$314,163	$27,230		$18,262	$11,559		$350,878	$2,000,000
Arizona [1]	31,947.35	975,801.95	10,000.00	1,017,749.30	608,677	191,093	$82,255	68,285	44,552	$22,888	1,500,000	1,000,000
Arkansas	41,778.52	221,831.24		263,609.76	229,997	16,304		9,808	7,500		700,000	1,700,000
California	26,399.00	6,941,192.00	29,179.00	6,996,770.00	5,237,420	(2)	894,921	324,720	234,392	305,317	6,500,000	[3] 14,649,868
Colorado	250,000.00	800,000.00	400,000.00	1,450,000.00	410,000	120,000	800,000	(4)	100,000	20,000	1,000,000	1,850,000
Connecticut	5,301.15	3,172,706.35	396,600.08	3,574,607.58	1,640,707	295,927	1,256,565	165,023	23,285	193,101	4,000,000	1,444,212
Delaware	5,268.40	429,734.43	208,373.86	643,376.69	606,606	8,050	2,153	24,632	1,936		1,500,000	300,000
Florida	9,972.55	179,807.22	328,722.38	518,502.15	389,111	3,664	80,092	33,321	8,196	4,118	732,430	5,245,703
Georgia	21,158.00	15,000.00	55,898.00	92,056.00	72,368	800		18,888	(5)		15,000	5,700,000
Idaho	48,936.00	491,342.00	479,642.00	1,019,920.00	651,033	133,796	115,540	93,423	22,384	3,744	1,000,000	2,500,000
Illinois		860,910.99	1,216,312.87	2,077,223.86	1,787,357	59,669	65,557	129,030	30,911	4,700	10,000,000	8,106,129
Indiana											4,000,000	13,000,000
Iowa	75,853.12	113,488.49	14,360,280.61	14,549,622.22	2,931,526	4,972,168	4,158,254	453,870	(5)	2,033,804	4,000,000	
Kansas	8,083.90	25,000.00	1,922,766.10	1,955,850.00	131,250	1,600,600		225,000	(5)		25,000	3,061,267
Kentucky		1,000,000.00	580,000.00	1,580,000.00	1,100,000	300,000	60,000	65,000	25,000	30,000	1,500,000	1,800,000
Louisiana [1]		182,295.00	358,681.00	540,976.00	430,708	35,984	9,841	42,107	20,060	2,276	200,000	3,000,000
Maine	81,611.96	1,570,493.75	707,309.05	2,359,414.76	1,333,776	263,500	613,805	60,129	42,941	45,265	2,010,000	1,500,000
Maryland	4,767.73	2,681,141.89	64,225.50	2,750,135.12	1,064,674	105,875	1,368,860	68,601	24,425	117,700	3,800,000	3,000,000
Massachusetts	33,440.00	3,522,493.89	568,369.00	4,124,302.89	1,389,153	3,150	2,365,794	188,688	60,535	116,984	4,597,500	5,000,000
Michigan [1]		1,704,359.00	3,968,794.00	5,673,152.00	5,125,224	187,751	247,178	62,000	43,000	8,000	2,000,000	5,000,000
Minnesota	224,357.76	1,870,336.01	3,300,216.08	5,394,909.85	3,146,867	942,119	1,000,867	(4)	305,057		2,529,049	5,172,801
Mississippi		10,000.00		10,000.00				2,500	7,500		10,000	750,000
Missouri		704,400.00	450,000.00	1,154,400.00	900,000		181,000	17,600	38,800	17,000	3,000,000	6,000,000
Montana		133,547.77		133,547.77	36,987	27,767		32,095	6,100	30,600	200,000	3,791,402
Nebraska	41,866.21	201,202.44	112,759.72	355,828.37	61,103	193,448	32,072	13,396	50,483	5,327	3,708,000	3,500,000
Nevada		75,327.59		75,327.59			16,467	21,581	20,638	16,642	650,248	399,442
New Hampshire	20,530.23	651,593.70	332,561.21	1,004,685.14	334,985		593,549	26,484	31,904	17,763	900,000	1,000,000
New Jersey [6]		1,848,932.41	1,860,000.00	3,708,932.41	606,587		2,800,922	87,321	114,696	99,407	5,500,000	3,000,000
New Mexico		527,071.57	487,120.53	1,014,192.10	487,261	96,912	249,284	39,587	6,085	135,063	1,205,000	300,000
New York [1]		9,432,679.00	2,282,452.00	11,715,130.65	5,635,027		4,537,709	1,108,622	273,874	159,899	14,000,000	9,000,000
North Carolina [1]		20,000.00		20,000.00				(4)	20,000		300,000	4,000,000
North Dakota	71,000.00	83,000.00	54,000.00	208,000.00	115,000	28,000	600	29,500	34,900		3,000,000	3,000,000
Ohio	169,075.76	4,670,270.22	3,660,487.75	8,499,833.73	6,272,840	(2)	1,791,244	200,926	133,584	101,239	4,000,000	6,000,000
Oklahoma		1,046,892.75	1,577,610.01	2,624,502.76	998,865	527,422	670,726	168,200	17,512	241,776	1,212,000	507,029
Oregon		2,120,551.24	709,724.79	2,830,276.03	1,948,936	617,388		162,384	63,491	38,076	5,000,000	4,000,000
Pennsylvania	137,437.17	[7] 8,041,833.86	574,605.09	8,753,876.12	1,694,011	279,359	5,473,193	227,335	260,267	[8] 819,711	16,000,000	6,000,000
Rhode Island	34,997.13	745,673.91		780,671.04		109,696	600,720	44,634	10,000	15,622	800,000	355,000
South Carolina	50,754.92	49,238.61	40,911.87	140,905.40	113,921	2,746		[9] 14,022	8,961	1,255	275,000	1,535,334
South Dakota		30,473.35	1,236.18	31,709.53	6,831			14,007	10,871		2,000,000	3,000,000
Tennessee		403,000.00	75,000.00	478,000.00	38,000		400,000	20,000	20,000		1,800,000	2,500,000
Texas	95,510.65	295,567.38	1,934,648.72	2,325,726.75	901,391		1,306,336	85,000	33,000		1,900,000	9,000,000
Utah		1,546,842.53	60,417.72	1,607,260.25	845,929	85,961	231,341	108,892	72,594	262,543	3,000,000	1,163,231
Vermont	5,000.00	778,075.00	223,000.00	1,006,075.00	494,000	55,000	445,000	2,075	10,000		800,000	600,000
Virginia	24,516.57	861,030.69	1,322,804.80	2,208,352.06	1,251,561	138,945	695,537	68,793	51,435	2,082	1,660,000	1,500,000
Washington	128,439.10	2,922,436.11	205,430.45	3,256,305.66	2,520,574	152,576	559,768	(4)	23,388		5,000,000	4,000,000
West Virginia	42,782.17	171,581.32	342,090.76	556,454.25	444,659	72,838	17,758	11,800	9,400		1,290,000	4,500,000
Wisconsin	225,319.00	2,051,455.00	3,307,401.00	5,584,175.00	3,175,126	993,966	1,250,000	(4)	165,083		2,500,000	3,700,000
Wyoming	59,053.61	67,582.26	121,071.74	247,707.61	163,198	17,773		39,146	11,736	15,855	2,000,000	681,507
Total and average.	2,108,538.86	66,351,478.24	48,825,251.07	117,285,267.82	57,647,409	12,667,477	34,974,908.	4,596,687	2,512,035	4,887,757	133,670,105	168,812,925

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[1] Data for 1917. Data for 1918 not available.
[2] Included under roads.
[3] Does not include San Francisco County.
[4] Included under administration.
[5] Included under engineering.
[6] Approximate.
[7] Does not include $943,765 State funds distributed to townships.
[8] Includes $384,975 for purchase of toll roads.
[9] Includes surveys for approximately 138 miles of proposed construction.

road improvement. Consequently, the full extent of the bond burden resulting from our past road and bridge expenditures is impossible of exact determination. Estimates based on the best available data would seem to show that there are at least $400,000,000 outstanding which are actually designated as road and bridge bonds or warrants. These are at present maturing at a rate in excess of $20,000,000 per year and a like or greater amount is required annually for interest payments. For a number of year past new road and bridge bonds have been issued at the rate of about $40,000,000, per annum and while there has been a marked decrease during 1917 and 1918, there is now abundant promise of a very decided increase.

STREETS COST ABOUT $300,000,000.

The expenditures on our city, town, and village streets are not included in these compilations as no complete records are available as to their amount. However, it is estimated that the expenditures on account of our streets amount in round numbers to $300,000,000 annually, or approximately the same as that expended on our rural roads and bridges. Many ɔ your city streets are in reality only extension or connecting links in our main highway systems.

TABLE II.—ROAD MILEAGE.

State.	Work done in 1918 under State supervision.			Miles of rural public roads.			State.
	State and State-aid roads built, 1918.	Roads maintained with State aid, 1918.	Number of bridges built by State or State aid, 1918.	Total all surfaced roads in State (approximate).	Total all public rural roads in State.	Percentage of surfaced roads in State.	
Alabama	[1]109		2	6,125	55,446	11.0	Alabama.
Arizona	52	436	10	475	12,075	3.9	Arizona.
Arkansas	(2)		(2)	2,000	50,743	4.0	Arkansas.
California	[3]260	2,521	11	13,000	61,039	21.2	California.
Colorado	[4]100	7,000	15	2,550	39,780	6.4	Colorado.
Connecticut	[5]55	1,481	13	3,200	14,061	22.6	Connecticut.
Delaware	10	20	1	310	3,674	8.5	Delaware.
Florida	[6]77	362	1	3,900	17,995	21.6	Florida.
Georgia	17		2	13,200	80,669	16.4	Georgia.
Idaho	[7]90	490	12	850	24,396	3.5	Idaho.
Illinois	[8]232	736	80	12,800	95,647	13.4	Illinois.
Indiana				31,000	73,347	42.5	Indiana.
Iowa	[9]2,969	104,682	[10]10,237	1,500	104,074	1.4	Iowa.
Kansas	19		(2)	1,550	111,052	1.4	Kansas.
Kentucky	[11]214	65	150	13,900	57,916	24.0	Kentucky.
Louisiana	(2)	(2)	(2)	2,700	24,563	11.0	Louisiana.
Maine	[12]160	4,235	19	3,525	23,537	14.9	Maine.
Maryland	192	1,433	5	3,100	16,459	18.8	Maryland.
Massachusetts	72	[13]2,000	1	9,100	18,681	48.8	Massachusetts.
Michigan	150			10,600	74,190	14.3	Michigan.
Minnesota	[14]1,643	12,089	[10]640	7,000	93,517	7.5	Minnesota.
Mississippi				2,700	45,779	5.9	Mississippi.
Missouri	[15]300	[16]11,400		7,550	96,041	7.8	Missouri.
Montana	[17]83		9	900	39,204	2.3	Montana.
Nebraska	[18]41		6	1,450	80,272	1.8	Nebraska.
Nevada		260		340	12,182	2.8	Nevada.
New Hampshire	[19]52	1,479		2,000	14,020	14.5	New Hampshire.
New Jersey	16	2,450		6,050	14,817	41.0	New Jersey.
New Mexico	[20]1,238	6,035	163	620	[21]43,091	1.4	New Mexico.
New York	(2)	(2)	(2)	18,400	79,398	23.2	New York.
North Carolina	(2)	(2)	(2)	6,850	50,758	13.5	North Carolina.
North Dakota	[22]110	65		1,160	68,796	1.8	North Dakota.
Ohio	[23]342	2,485	7	31,800	86,354	36.8	Ohio.
Oklahoma	[24]927	2,592	614	700	107,916	.7	Oklahoma.
Oregon	[25]213		60	5,000	36,819	14.1	Oregon.
Pennsylvania	44	8,495	167	10,600	91,556	11.6	Pennsylvania.
Rhode Island	[26]15	325	12	750	2,170	34.5	Rhode Island.
South Carolina	11		1	3,800	42,226	9.0	South Carolina.
South Dakota	(2)			800	96,306	.8	South Dakota.
Tennessee	12	3,800		8,880	46,050	19.2	Tennessee.
Texas	200	13,000		12,300	128,960	9.6	Texas.
Utah	109	367		1,650	8,810	18.6	Utah.
Vermont	110	4,300		2,300	14,249	16.3	Vermont.
Virginia	[27]378	3,054	39	6,150	53,388	11.7	Virginia.
Washington	[28]275	1,411	6	6,300	42,428	14.9	Washington.
West Virginia	[29]135	88	12	1,600	32,024	5.0	West Virginia.
Wisconsin	[30]735	5,000	670	15,500	77,280	20.1	Wisconsin.
Wyoming	[31]167		8	600	14,797	4.1	Wyoming.
Total and average	11,944	203,556	12,973	299,135	2,478,552	12.0	Total and average.

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[1] Includes 12 miles of earth roads.
[2] Data not available.
[3] Includes 87 miles of earth roads.
[4] Includes 64 miles of earth roads.
[5] Includes 34 miles of reconstruction.
[6] Includes 5 miles of earth roads.
[7] Includes 75 miles of earth roads.
[8] Includes 64 miles of earth roads.
[9] Includes 2,549 miles of earth roads.
[10] Includes culverts.
[11] Includes 45 miles of earth roads.
[12] Includes 5 miles of earth roads.
[13] Includes about 792 miles of town roads.
[14] Includes 1,207 miles of earth roads.
[15] Includes 245 miles of earth roads; does not include 200 miles partially completed.
[16] Dragging only.
[17] Includes 32 miles of earth roads.
[18] Includes 36 miles of earth roads.
[19] Includes 9 miles of reconstruction.
[20] Includes 1,063 miles of earth roads.
[21] As reported by State highway engineer May, 1919.
[22] Includes 100 miles of earth road.
[23] Includes 22 miles of earth roads.
[24] Includes 716 miles of earth roads.
[25] Includes 100 miles of earth roads.
[26] All reconstruction.
[27] Includes 44 miles of earth roads and 52 miles of reconstruction.
[28] Includes 140 miles of earth roads.
[29] Includes 111 miles of earth roads.
[30] Includes 373 miles of earth roads.
[31] Includes 144 miles of earth roads.

With the present tremendous development of motor truck and automobile traffic these streets become an important and vital factor in the efficient operation and functioning of our general highway system, and especially to any general plan of motor hauling involving the delivery of country produce. It is, therefore, hoped that more definite data in regard to the extent, cost, and conditions of our city streets may soon be available.

TABLE III.—CASH ROAD AND BRIDGE EXPENDITURES FOR CALENDAR YEARS 1904, 1914, 1916, 1917, AND 1918.

State.	Year in which first State-aid law passed.	State funds expended by or under State highway department.					Total cash expenditure from all sources (approximate).				
		1904	1914	1916	1917	1918	1904	1914	1916	1917	1918
Alabama	1911	....	$170,232	$102,422	$89,511	$103,285	$378,040	$3,949,019	$4,186,384	$2,669,022	$2,371,213
Arizona	1909	....	....	441,202	543,422	975,802	67,591	982,721	1,988,221	1,569 422	2,017,749
Arkansas	1913	....	115,000	55 483	81,262	221,831	681.934	1,522 696	3,443.887	3,335,262	1,963,610
California	1895	$11 271	......	4 285 964	3,058,030	6,941,192	2,157,396	19,171,985	20,392 434	18,245,200	21,646,638
Colorado	1909	..	301,274	607,628	703,000	890,000	635,395	1,937,546	2,313,208	2,570,000	3,300,000
Connecticut	1895	219,165	1,307 381	1,865,948	2,197,264	3,172 706	1,195,125	3,640,963	3,200,948	4,004,225	5,018,820
Delaware	1903	11,000	31,000	31,000	21,600	429 734	90 803	511,628	512 000	321,600	943,377
Florida	1915	....	....	10,484	23,797	179 807	437,184	2,280,255	4,010,484	6,381 797	5,764,205
Georgia	1908	....	....	....	1 910	15,000	894 936	3,688,172	3,750 000	4,318,350	5,792,056
Idaho	1905	....	49,812	100,057	473 132	491 342	201,648	1,371,469	1,948,118	2,092,723	3,519 920
Illinois	1905	....	387,989	1,119,202	1,258,338	860,911	3 844 424	8,734 713	10 356 669	10,083 728	10 183 353
Indiana	1917	....	....	....	14 000	....	3 138 389	14,233,986	13 500,000	14 014 000	13,000,000
Iowa	1904	....	74,000	90,821	89 787	113,488	2 344 107	10,187,507	14,427,877	15,625 406	14,549 622
Kansas	1911	....	9 080	10,000	10,000	25,000	692,823	5,544,048	5,610,000	6,010 000	5,017,117
Kentucky[1]	1912	....	18,000	708 396	1,501,650	1,000,000	1,161,194	2 474 621	4,448 533	4,923,651	3,380,000
Louisiana	1910	....	161,186	184,533	182 295	182,295	345,452	1,777 572	3,458,643	3,540,976	3 540,976
Maine	1901	14 885	467 149	1,055 250	1,112,675	1,570,494	1,472 393	2 042 007	3,167,215	3,244,982	3,859,415
Maryland	1898	....	356 845	2 280 000	2,804,707	2,681,142	873,471	6 001,052	5,560 000	6 083 682	5,750,135
Massachusetts	1892	575 606	242,560	2 701 236	4,231,802	3,522 494	2,871,222	6,091 875	6,499 141	9,494 802	9 124,303
Michigan[1]	1905	....	657,264	982,939	1,704 359	1,704 359	1,816,504	9 261 998	10 082,939	11,190,153	10,673,153
Minnesota	1905	....	1,309,956	1,390,525	1,429,865	1,870,336	1,607,417	6 458 940	8 742 278	8 024 760	10 567,711
Mississippi	1915	....	....	6 500	6,500	10,000	339 669	3,960,377	3,256,500	3,256,500	760,000
Missouri	1907	....	277,253	482,860	367 913	704 400	1,570 801	5 513 049	7 982 860	7,374 933	7,154,400
Montana	1913	....	13,516	26 150	25,729	133,548	308 744	2,888,400	3 475 569	3,356,869	3,924,950
Nebraska	1911	....	....	110,000	9,500	201,202	491,886	1,796 278	4 500 000	4 603 400	3,855 828
Nevada	1911	....	....	....	36 796	75,328	16 876	215,014	275,000	336,796	474,770
New Hampshire	1903	44 000	491,520	414 669	589 254	651,594	872,606	1,590 464	2 045 410	2,238,705	2,004 685
New Jersey	1891	250 000	1,306,596	1,167 843	1,501,902	1 848 932	3,274,811	7,208 287	5,784,354	6 280 897	6,708 922
New Mexico	1909	....	115,732	385,684	280 578	527 072	35 458	556 399	828 952	845,867	1,314,192
New York[1]	1898	1,056,460	8,544,126	9,409,655	9,432,679	9,432 679	3,937,739	23,231,964	19 901 391	21,685,131	20,715,131
North Carolina[1]	1901	....	5,000	10,000	20,000	20,000	624 381	5,215 491	5 510 000	5,520 000	4,020,000
North Dakota	1909	....	....	....	28 638	....	456 130	2,402,384	2,711 295	2 867 979	3 208 000
Ohio	1904	....	1,855,338	2,885,071	2,835,649	83 000	4,776 318	14,334 246	12,992,625	12,017,104	14,499 834
Oklahoma	1911	....	....	300 000	286 922	4,670 270	447,320	2 112 681	3,625 000	3,722 355	3,131,532
Oregon	1913	....	10,697	165,662	711 000	1,046 893	649 718	5 310,467	5 955 662	5,711,000	6,830,276
Pennsylvania	1903	127,767	1,976,768	3,663 352	4,351,566	2,120,551	4,887,266	10,424 580	10,985,392	11,463 333	14,753,876
Rhode Island	1902	79 397	....	543 152	486,725	8,041,834	376,812	446 496	943,152	861,725	1,135,671
South Carolina	1917	....	....	....	27,161	745,674	334 082	1,024 480	1,250,000	1,277,161	1,676,239
South Dakota	1911	....	....	....	5,000	49 239	268,723	1 217,809	2,708,000	2,755 090	3 031 710
Tennessee	1915	....	....	200,000	231,500	30,473	629,141	2,370,560	4 600 000	2,481,500	2,978 000
Texas	1917	....	....	....	10 000	403 000	2,543,613	9 920 079	10,500 000	10 010 000	11 325 727
Utah	1909	....	157,732	179,400	120,200	295,567	158 286	803 071	1,855,160	1,893 129	2,770 491
Vermont	1898	127,381	458 456	632,800	578,883	1,546 843	567,397	1,023,941	1,607,800	1 680 489	1 606,075
Virginia	1906	....	523,578	542,524	695 171	778,075	687,751	3,224 529	3 691 249	4 136 779	3 708 352
Washington	1905	....	1,343,431	859 672	2,031,392	861,031	1,344,842	7,944,717	7,518 343	7,115,691	7 256 306
West Virginia	1909	....	....	10 967	....	2,922,436	587 870	2,183,747	5,510,967	8 200 000	5,056 454
Wisconsin	1911	....	1 482,379	950,000	1,050,888	171,581	1,924 026	9,880 240	10,570 764	9,886 554	9,284 175
Wyoming	1911	....	....	....	37,845	2,051,455 67,582	74,476	669,661	450,000	589,691	929,215
Total		2,549,850	24,220,850	40,969,001	47,290,796	66,351,478	59,427,180	240,263,784	272,634,424	279,915,332	286,098,113

[1] Data for 1918 not available; state expenditures shown in 1918 column are for the year 1917.

AVERAGE INCREASE SHRINKS.

The abnormal conditions during 1917 and 1918 had a very decided effect on road and bridge work. From 1904 to 1916 the average annual increase in the total rural road and bridge expenditures was about 10 per cent over and above those of each previous year. During the years 1917 and 1918, however, this increase was reduced to about 2½ per cent. The part which the several States pay in comparison with that of the local subdivisions, on the contrary, has continued to increase at a uniformly rapid rate. In 1904 eleven State highway departments expended a total of $2,550,000 for road and bridge work, and in 1914, thirty-one State highway departments expended $4,221,000. In 1917 every State in the Union participated and the total expenditure of State funds amounted to $47,291,000. In 1918 this had reached a total of $66,351,000.

The utilization of convict labor in road work or in the preparation of road materials under competent state supervision is coming to be a more and more important factor, while the employment of statute labor or working out of poll taxes is steadily decreasing from year to year. At the present time in more than one-half of our States the use of convict labor has definitely passed the experimental stage and has been established as a success.

CENTRALIZING CONTROL OF WORK.

One of the most notable features in the development of our road and bridge work is the increase in the amount of funds expended for road maintenance under the supervision and control of the several state highway departments. In 1914 the several State highway departments directed the expenditure of $16,343,000 for maintenance. In 1917 this had increased to $27,649,000, while in 1918 it reached a total of $34,974,908. This increase is in part due to the heavier traffic and the rising prices of labor and materials, but more largely to the growing tendency to centralize the control of all our important highway work under competent State control and supervision.

While highway construction during the year 1918 was considerably curtailed, especially by the local subdivisions, extraordinary traffic development required a large amount of improvement and reconstruction of a quite substantial nature. The reason for these construction demands are readily apparent. At the present time approximately 6,000,000 motor vehicles, of which about 10 per cent are motor trucks and other commercial vehicles, are used on our public roads and streets. If each of these vehicles averaged only 5,000 miles a year, which is certainly a low estimate, the total traffic of all our motor vehicles will amount to approximately 30,000,000,000 vehicle miles per year. Furthermore, it is a well known fact that at least 75 per cent of the total traffic is concentrated on about 20 per cent of our rural public roads. Consequently, the reason why our roads are requiring so much greater expense and effort for adequate maintenance is readily apparent. This motor traffic, furthermore, has grown up almost entirely within the last 15 or 18 years and is entirely in addition to the horse-drawn traffic which, with the exception of pleasure vehicles, is probably as large as ever. At the present time the horse-drawn traffic on most of our roads forms less than 10 per cent of the total.

TRAFFIC TOO HEAVY FOR MANY ROADS.

The public roads of the United States at the present time have a total length of 2,478,552 miles, of which about 299,135 are improved with some form of surfacing. A large portion of this mileage, however, is comprised of sand-clay, gravel, or water-bound macadam, much of which is proving entirely inadequate for the present-day traffic and is rapidly deteriorating. During 1918 there was improved by the several State highway departments a total of 11,944 miles, of which about 7,000 consisted of grading, most of which was preparatory to later surfacing. In addition to this construction the several State highway departments also supervised the maintenance of 203,556 miles, most of which were main and trunk line highways.

The expenditures for 1918 by or under the various State highway departments are shown in Table 1 and the work accomplished is shown in Table 2. Table 3 shows the expenditures from purely State funds for the years 1904, 1914, 1916, 1917, and 1918, and also the total combined State and local expenditures for the same years. In Table 1 the columns under "administration" and "engineering" show a considerable variation in the percentage devoted to these purposes in each of the several States. These variations are probably due more to difference in bookkeeping and definition as to what items should be included under these heads than any other cause. There is a great need for common standards in regard to these items so that such expenditures may be fairly comparable as between the several States. This also applies to the term "reconstruction" and "maintenance." In some States practically all reconstruction work is classed under maintenance, while in others it is classed entirely under construction and in still others it is kept as a separate item and designated as reconstruction.

These compilations include no expenditures for road or street work by the War or Navy Departments and similar agencies in or at cantonments, training stations, or other places.

LARGEST COUNTY BOND ISSUE.

July 1 St. Louis County, Minn., by a vote of about 9 to 1, carried a proposition for the issuance of road bonds to the amount of $7,500,000. This is the largest sum ever voted or set aside at one time for road building by any county in the United States. The second largest was that of Dallas County, Tex., which voted a few weeks ago for $6,500,000.

The St. Louis County bonds are to be used for the construction of 270 miles of road under the Babcock plan. Under the act passed by the Minnesota Legislature last winter submitting to the people of the State at the regular election in 1920 a vote on a bond issue of $75,000,000 there is a provision that the money raised is to be used for building a system of State roads which are named in the law. The St. Louis County funds are for roads which will become a part of that system.

St. Louis is the great iron-ore mining county of the Lake Superior district, and has within its limits the largest and most valuable deposit of iron ore known. There are several cities and towns in the mining district of from 5,000 to 15,000 people. From Duluth, the county seat, on the south edge the county stretches to the north to the Canadian boundary, a distance of about 110 miles, and it has an average width of about 60 miles. The population in 1910 was 163,700 and is now about 200,000. One of the roads in the Babcock plan will traverse the county from Duluth to the northern boundary, passing through the Mesaba iron range. This road from Duluth to the mining region, a distance of 75 miles, is to be paved. No district in the county voted against the bond issue.

PRELIMINARY REPORT OF IMPACT TESTS OF AUTO TRUCKS ON ROADS

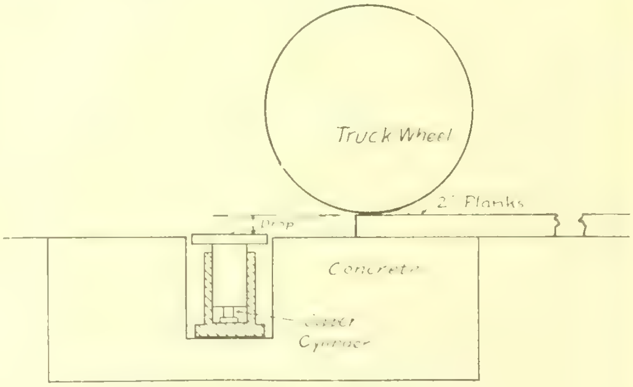
By E. B. SMITH, Sen. Asst. Testing Engineer, and J. T. PAULS, Highway Engineer.

REALIZING the destructive effect of heavily loaded auto trucks on highways and streets, and the demand for data on the design of road surfaces and foundations to withstand such heavy traffic, a series of experiments is being conducted by the Bureau of Public Roads at the Arlington Experimental Farm to determine the impact of auto trucks on roads.

The apparatus used in these experiments consists of a heavy steel cylinder in which is fitted a plunger 4 inches in diameter and 8 inches long, similar in construction to a hydraulic jack. A hole is left in the bottom of the cylinder in order to prevent air cushioning under the plunger. On the top or head of the plunger there is securely fastened a heavy steel plate, on which the impact of the truck wheel is received. This whole apparatus is supported rigidly in a concrete box placed in the road in such a position that the height of the steel plate on top of the plunger may be made just flush with the road surface. The height of the upper surface of the plate can be varied by proper steel disks placed under the plunger. In order that the front wheel may pass over and not touch the steel plate on the plunger, a steel bridge is used which is automatically tripped by the front wheel in passing over it. This releases a catch and allows a weighted lever to pull the bridge clear from the apparatus, thus leaving the steel plate exposed and ready to receive the impact of the rear wheel. By slight variations this bridge may be used to allow the impact of the front wheel to be received and then protect the plate from the impact of the rear wheel. The approach to this impact apparatus is made of 2-inch planking about 20 feet long and is so constructed that the height of the planks may be varied above the road surface to give various heights of drop, and also can be moved forward or backward to give the proper jumping distance from the jump-off point so that the wheel will strike the center of the plunger at all speeds.

RECORDING THE IMPACT VALUE.

For recording the impact value a copper cylinder one-half inch in diameter by one-half inch long is placed under the plunger of the jack. The impact received on the plunger is transmitted to the copper cylinder, where it produces a corresponding permanent deformation. The copper cylinders for this investigation are prepared from pure copper bars and are carefully machined to dimensions. They are then annealed by heating for 30 minutes at a uniform temperature of 650° C. in a bath consisting of a mixture of 20 per cent potassium nitrate and 80 per cent sodium nitrate, followed by cooling slowly in the air at room temperature. This treatment anneals the copper very uniformly. The finished cylinders are tested for uniformity in a universal testing machine under a pressure of 6,000 pounds total static load, five cylinders being taken from each heat-treated lot. Thus far the maximum variation from the mean deformation value has been only 1.3 per cent, and this is less than other experimental errors.



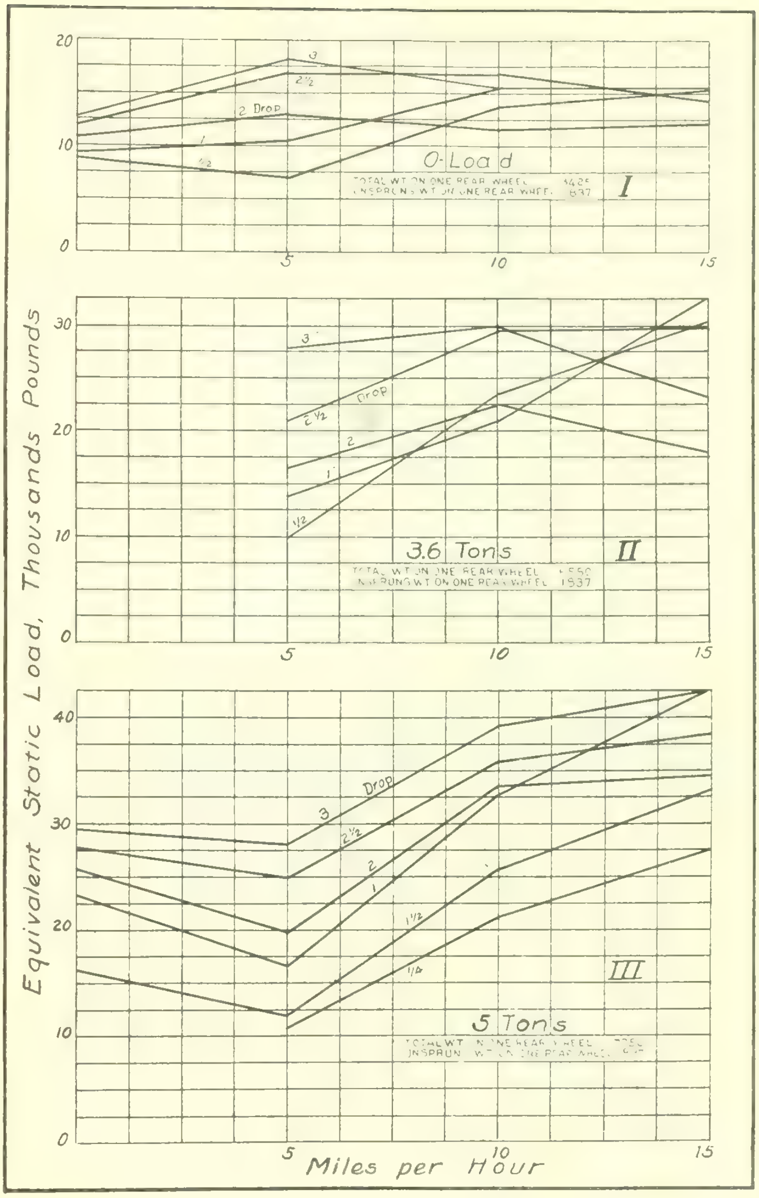
APPARATUS USED IN MAKING TESTS.

A 3-ton U. S. A class B truck with solid rubber tires was used for these experiments. The weight of the truck empty is 11,400 pounds; weight on front wheels, 4,550 pounds; weight on rear wheels, 6,850 pounds; weight of unsprung rear parts, 3,675 pounds. Deflection of rear spring under weight of body alone is 0.74 inch. Weight on rear wheels when loaded with 7,200 pounds (3.6 tons) gravel is 13,100 pounds; deflection of rear spring, due to load and body, 2.62 inches. Weight on rear wheels when loaded with 10,000 pounds (5 tons) gravel is 15,500 pounds; deflection of rear spring, due to load and body, 3.62 inches. Diameter of rear wheels is 40 inches, each fitted with two solid rubber tires, and each tire is 6 inches wide at the base next to the rim. Impact values were obtained only for the rear wheel, as it was the object to obtain values of the maximum impact of the truck. Rear springs were 57½ inches long, 4 inches wide, 6½ inches deep, with 17 leaves.

THE TEST CONDITIONS.

The impact condition under which these tests were conducted was the simple falling of the truck wheel from one level to another at different speeds of the truck; the height of drop varying from ¼ to 3 inches. Other conditions of impact will be investigated later. The magnitude of the impact is dependent upon: (1) height of drop, (2) weight of truck and load, (3) kind and condition of tires, (4) characteristics of springs, and (5) speed of truck. Under these conditions, a series of tests were run, and the results are shown on the accompanying curves.

The impact, while measured by the shortening or compression of the copper cylinders, is shown in equivalent static load. That is, for each compression value of the copper the static load has been determined which would produce the same compression. All the curves are thus shown with the equivalent static load as ordinates. This may not be a perfect comparison of impact loads, as loads applied with impact will probably produce a much localized shattering effect which does not result from the application of an equivalent static load. For this reason, the present methods of comparing impacts by their equivalent static loads must be considered as tentative and subject to possible revision as the tests proceed.



ELEMENTS OF DESTRUCTIVE EFFECT.

The tests thus far give only the relative impact values, and do not attempt to demonstrate the destructive effect of these impacts. The destructive effect depends upon the road surface, the type of construction, and the foundation, and to arrive at the destructive effect of these impact forces, it is proposed in another series of experiments to subject certain road surfaces to these same impacts repeatedly until failure occurs. Machinery and apparatus for this purpose are now under construction.

The results as shown in curves I, II, and III indicate a general tendency of increased impact toward the higher speeds, although the increment of increase is less as the speed increases. The relatively high impact values at zero speed, as shown in curve III, are explained by the fact that the results were obtained by dropping the wheel vertically upon the impact plunger, which resulted in the copper cylinder receiving, first, the impact, or kick of the spring, then an additional load an instant later from the falling of the truck body and load. Curves IV, V, and VI show the same data plotted with height of drop as abscissæ. These curves indicate a general increase of impact with the increase of height of drop.

[Continued in next column.]

SPRINGS HAVE GREAT INFLUENCE.

In conducting these experiments it was soon discovered that the action of the truck springs had a great influence on the impact results. When the wheel leaves the jump-off point the spring snaps open and produces a greater downward acceleration of the unsprung parts than that due to the action of

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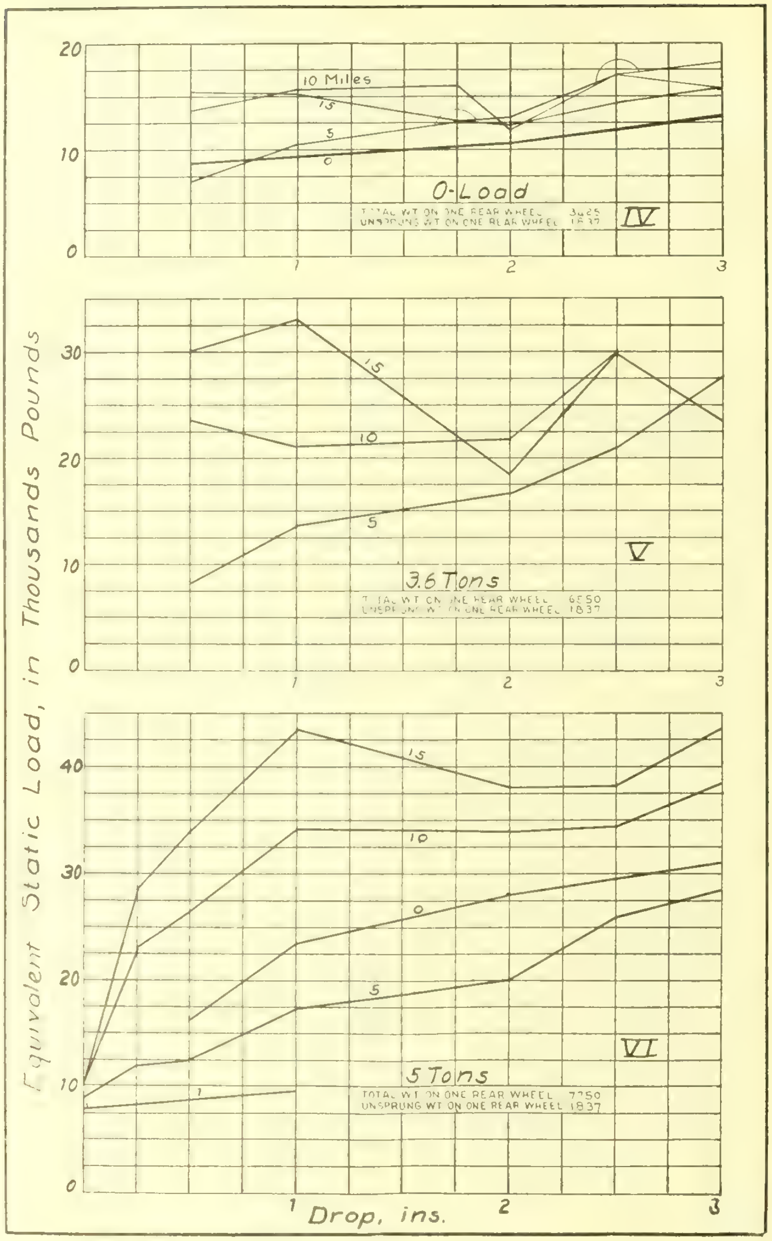
BONDS BRING PREMIUM.

Twenty-three bids were made for the $12,000,000 of Pennsylvania State road bonds, the first allotment of the $60,000,000 in bonds voted last fall. The issue is to be put out in blocks of $2,000,000 at 4½ per cent, maturing in 5, 10, 15, 20, 25, and 30 years. The highest bid was $103.52.

gravity alone. If the compression of the spring is e and the height of the drop or jump-off point is d, then within the time of one vibration of the spring, the magnitude of the impact at the landing point will depend upon whether $d<e$, or $d=e$, or $d>e$. If the period of vibration is such that the spring has acquired its maximum acceleration, and at this instant also lands at the point of impact on the road surface, the impact value will be a maximum. The impact value will be a minimum when conditions are such that the spring is returning to its closed position and is at the point of maximum acceleration in this direction as the impact occurs. This explains why the impact values, as shown in the curves, do not consistently increase with the height of drop. The static loads equivalent to the impact values under the higher loads and drops are as much as five times larger than the total dead load.



POWER INCREASES IMPACT.

It was also noticed during these tests that the impact was appreciably affected by the conditions of power on or off. That is, if the impact occurred when coasting it was less than when the power was being applied to the rear wheels. This difference amounted in some cases to as much as 30 per cent.

These results are presented at this time only for the purpose of showing the general tendency of impact values. It is the intention to enlarge upon this investigation to determine the relative effects of kinds of tires, loads, speeds, spring characteristics, and character of road obstructions and defects which produce impact values, and attempt to arrive at some definite conclusions as to the destructive effect of truck loads on different types of roads. It is hoped that this will ultimately result in definite road design data, and also lead to the establishment of rules and laws for the allowable loads and speeds of auto trucks, and possibly furnish an equitable basis for license fees. Special apparatus is being designed to obtain autographic records of these tests.

$2,000,000 FOR ROADS.

A bond election is proposed for this fall in Emmet County, Mich., for from $350,000 to $500,000 for highway construction. This amount is to be part of a program which will call for a total expenditure of about $2,000,000.

FOR HARD SURFACE ROADS.

Iowa is moving for hard surfaced highways. Elections have been held in a number of counties since June 1 on the question of hard surfacing roads. Fourteen counties voted favorably and in four counties the proposition was defeated. In addition to voting for hard surfaced roads these counties voted for bond issues to build the roads faster than current appropriations will permit: Woodbury County, $3,000,000; Polk and Scott Counties, $2,000,000 each; Black Hawk and O'Brien Counties, $1,500,000 each, and Cerro Gordo, $750,000. Palo Alto County, while voting in favor of hard surfaced roads, defeated a proposed bond issue of $750,000.

A number of other counties will hold elections in regard to hard surfacing and four or five on proposed bond issues between this time and November.

TESTING AGGREGATES IN THE FIELD

By F. H. JACKSON, Assistant Testing Engineer.

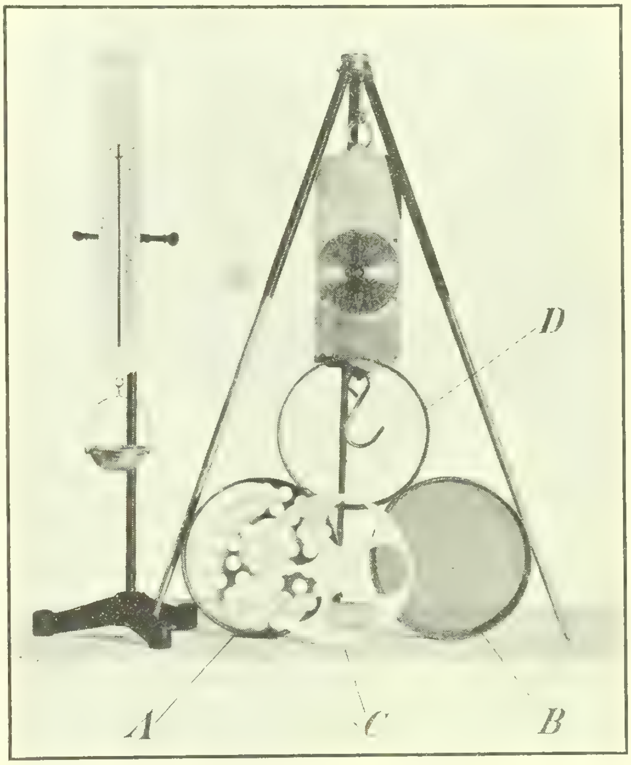
A FACTOR which probably tends more than any other to discourage adequate control testing of highway materials is the time usually required to send samples to a laboratory for test purposes. Even under the most favorable conditions several days may elapse before a report can be secured, during which time the lot of material represented by the sample must be held. Conditions frequently are such that an engineer or inspector must decide at once upon the arrival of a shipment whether to accept or reject it, so that, unless he is provided with equipment for making tests himself, he must base his decision solely on visual inspection.

Although an inspector ordinarily may be able to reject a consignment without question, instances often arise when even the most expert may be in doubt. This is especially true in connection with determinations of the grading or size of aggregates. These materials always are subject to variations in size due to inefficiency in plant screening and other causes and yet may be intended for use in construction requiring uniformly graded aggregates. An examination, of course, may be made in such cases with the ordinary laboratory equipment. Such equipment, however, is bulky and difficult to move from place to place, and therefore is not adapted to field use, so that up to the present time there has been little or no systematic control testing in the field. The obvious solution is to supply a field equipment which will accomplish the same purpose and still be compact, light, and capable of withstanding a certain amount of rough usage. A description of such an outfit which has been developed recently by the Bureau of Public Roads, together with suggested methods for its use, follows:

DESCRIPTION OF APPARATUS.

The field equipment so far developed consists of the following units:

1 set interchangeable stone screens, with screen plates having perforations 3, $2\frac{1}{2}$, 2, $1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$, and $\frac{1}{4}$ inch in diameter.
1 set interchangeable sand sieves, of 10, 20, 30, 40, 50, 80, 100, and 200 mesh.
1 circular spring scale having a capacity of 30 pounds and sensitive to 0.1 pound.
1 straight spring balance having a capacity of 200 grams and sensitive to 1 gram.
1 demountable cubic foot box.
1 ordinary camera-folding tripod.
1 250 c. c. graduate.
1 strip of screen wire about 22 inches in length and 5 inches high.
2 canvas bags about 18 by 18 inches in size.



APPARATUS FOR MAKING FIELD ANALYSIS OF AGGREGATES.

The interchangeable screens used in this equipment were developed in the course of a field study of stone and slag crushing practice which was undertaken recently by the Bureau of Public Roads. They have been used for obtaining mechanical analyses of coarse aggregates, substantially as described below, by engineers of the Bureau throughout two field seasons and have given uniformly satisfactory results. The set consists of a number of perforated screen plates 8 inches in diameter, and two brass rings, one of which is provided with a narrow shoulder on the inside upon which a screen plate may be placed. The two rings are then firmly clamped together so that the screen plate is held rigidly between them. This forms a screen of the same size and shape as the ordinary laboratory type. When not in use all of the plates may be clamped together in the ring so that the whole set takes up no more room than a single laboratory screen.

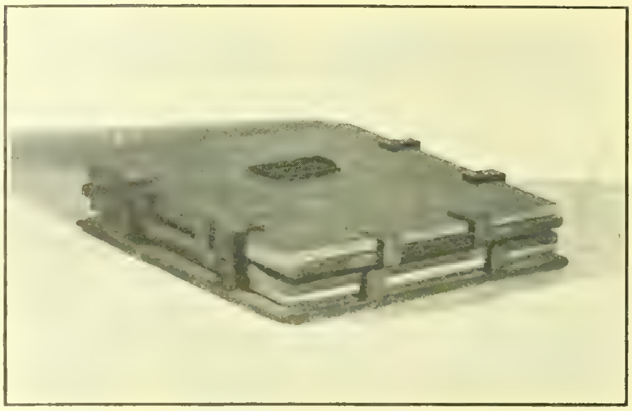
The circular spring scale is equipped with a loose pointer for obtaining the net weight of the material being examined. It is graduated in 0.1-pound divisions and one complete revolution of the pointer equals 10 pounds. The scale has a total capacity of 30 pounds or 3 revolutions of the pointer.

The sand sieves are of the same general type as the screens, the various sieve plates fitting into the brass rings in the same manner. Thus, a sieve of any desired mesh may be made up by simply inserting the proper sieve plate in the lower ring and clamping it down by means of the upper ring. A soft rubber washer is placed over each sieve plate so that the upper ring will clamp down on it, thus making a dustproof joint. The straight spring balance is of a special type graduated on one side from 0 to 200 grams by 1 gram divisions and on the other side from 0 to 100 per cent by 1 per cent divisions. It is used in making mechanical analyses of fine aggregates. An aluminum cup is provided large enough to hold a 200-gram sand sample.

In the illustration of this equipment the circular screen scale is supported by the tripod in the way it would be in practice. A screen plate inserted in the lower ring is shown at A, a sieve plate inserted in the ring is shown at B, C shows a screen plate before insertion in the ring, and D the upper, or clamping, ring. The 250 c. c. graduate is the only piece of glass in the outfit and is needed only when it is desired to make volumetric silt determinations. The circular loop of screen wire is used for making apparent specific gravity determinations of coarse aggregates. The object of the strip is to increase the capacity of a screen so that it may be used for weighing samples of sufficient size for this determination. It is rolled in the form of a loop and placed inside of the screen ring which in turn is suspended from the spring scales by means of three light wires.

The demountable cubic foot box is used for determining weight per cubic foot of crushed slag and other coarse aggregates. It is made of five pieces of light strong wood ⅜ inch thick, the bottom 12¾ by 12¾ inches, two sides 12 by 12¾ inches and two sides 12 by 12 inches. The four sides are first slipped into place and held by the notched brass angles shown in the illustration. The bottom is then slid into place in the angles provided on three of the sides. Field experience with this measure has suggested that the wooden bottom be protected on the outside by a sheet of thin metal. This would materially increase the life of the apparatus. In making sieve analyses this box is very handy for catching the fines. When collapsed the box consumes little more space than the actual volume of the material. When made of poplar the total weight is 7 pounds. Oak, while harder, would increase the weight a pound or so.

The total outfit described above weighs approximately 18 pounds. The apparatus making screen and sieve analyses weighs approximately 10 pounds and may be packed in a space measuring 17 by 8 by 6 inches.



CUBIC-FOOT BOX COLLAPSED.

SUGGESTED METHODS FOR SAMPLING.

The importance of the proper sampling of materials in connection with the field testing of aggregates can not be overemphasized. It is the one branch of testing work to which the least attention is paid, and yet, if sampling has not been done properly, the most carefully made tests are worse than valueless. For this reason, unless the inspector is prepared to spend the necessary amount of time in taking samples, he should not attempt to make any tests whatever.

There are two points which must be borne in mind when sampling crushed stone and gravel aggregate. In the first place, the sample must be representative of the entire quantity being examined; and in the second place it must be large enough so that the largest individual piece will in no case weigh more than 2 per cent of the weight of the entire sample. When sampling crushed stone or gravel from cars or trucks a sufficient quantity should be taken from each end as well as from the top and bottom of the car to insure an average of the entire shipment. A shovelful taken from the top is not sufficient. A composite sample should then be prepared by thorough mixing after which it should be reduced by quartering until a sample has been secured weighing at least 50 times the weight of the largest fragment present.

In sampling from stock piles on the job, at the plant, or from bins the same precautions as noted above should be observed. Sampling from cars or trucks before or after delivery is much to be preferred to sampling from bins, because of the greater ease in obtaining average samples.

In sampling sand one of the principal precautions to be observed is to see that the sample taken contains an average amount of the loam or clay present in the shipment. Samples should be obtained whenever possible from damp sand, owing to the difficulty of obtaining a truly representative grading when the sand grains are dry. A composite sample weighing 10 pounds made up of samples from each end and from the top and bottom of the car should be taken.

USE OF APPARATUS.

In making a mechanical analysis of a crushed stone aggregate with this apparatus a number of points should be noted. The tripod should be set up and the circular spring scale suspended from it as close as possible to the material being examined. The shipment should then be sampled in accordance with the given suggestions. The whole sample thus prepared may then be passed through the various screens and the percentage by weight retained on each calculated; or, in the case of mixed aggregates graded up to 2 or 3 inches in size, a number of determinations may be made and the results averaged. It has been found convenient to make the original weight of each sample 10 pounds or some multiple of 10 pounds. Inasmuch as the dial of the scale is graduated by one-tenth pound divisions, the various weights may then be read either as percentages direct or converted into percentages by simple calculation.

In making sieve analyses of sand or stone screenings less than one-quarter inch in size the straight spring balance should be used. A 100 or 200 gram sample may be dried in any convenient manner and a mechanical analysis made in the ordinary way, using the interchangeable sieve plates. If a 200-gram sample is used the percentage of material retained on each sieve may be read direct from the scale. A mechanical analysis made in this manner on materials containing an appreciable amount of clay or loam, especially if it occurs as a coating on the sand grains, will not be absolutely comparable with a laboratory analysis. It will give, however, a fair indication of the grading of the material sufficient in most cases for control work.

VOLUMETRIC SILT DETERMINATIONS.

Volumetric silt determinations should be made on all sand used in concrete work. Inasmuch as there is no definite relation between the silt content as determined by weight and by volume, it is recommended that the laboratory making the preliminary tests on the sand report the silt content in both ways. This will make it possible for the inspector to compare his results with the specification requirements which are nearly always written on the weight basis. The following suggested methods for making a volumetric silt determination may be used: A 250 c. c. glass graduate is filled to the 100 c. c. mark with water. Sand is then poured in up to the 100 c. c. mark after which the graduate is thoroughly shaken. After allowing the sand to settle until the water is approximately clear the volume of silt may be read and its percentage calculated from the total volume of the sand in the graduate. The line of demarkation between the silt and the sand is usually very distinct.

A quick determination in the field of the apparent specific gravity of an aggregate is sometimes of value, especially in the case of very heavy or very light materials. It may be made easily and fairly accurately with the equipment described. A screen fitted with a loop of screen wire and suspended from the large spring scale is filled with the aggregate to be examined and its weight recorded. A 10-pound sample may be used conveniently. The entire container, together with the sample, is then immersed in water and immediately reweighed. The apparent specific gravity may be computed from the loss of weight. An ordinary bucket of water may be used for immersing the sample. Numerous tests made with his apparatus indicate that results accurate to at least the first decimal place may be assumed.

CUBIC-FOOT BOX SET UP.

WEIGHT PER CUBIC FOOT DETERMINATION.

The determination of the weight per cubic foot is of value principally in the case of slag. The demountable box previously described affords a convenient way of making this determination on the job. The method so far used is to shake the material to refusal in layers of 3 inches each, striking the box upon the ground by rocking it back and forth twenty times after each layer has been deposited.

The systematic use of a field equipment similar to that described should prove of value both in the plant and field inspection of highway materials. A number of uses of the various units comprising the equipment will suggest themselves to engineers. For instance, the interchangeable sieves and small spring balance may be very conveniently used in sheet asphalt control work. In proportioning aggregates for various types of bituminous concrete roads, the outfit should prove of value. In fact, it may be used advantageously in any work in which a rapid determination of the size or weight of aggregate is desired.

Detailed information regarding the manufacture and use of any of the equipment described above will be given upon application to the Bureau of Public Roads.

IN TWO GEORGIA COUNTIES.

Elections will be held in the near future in Muscogee and DeKalb Counties, Ga., on proposed highway bond issues. In the latter the proposition is for an issue of $750,000 and in the former for one of $740,000.

CALIFORNIA BOND ISSUE.

California voted by about 7 to 1, July 1, in favor of the proposed constitutional amendment providing for a bond issue of $40,000,000 to complete the State highway system. In addition to this $40,000,000 there is available for the system $3,000,000 from the appropriation of 1915–16, about $6,000,000 provided by counties for laterals from the burden of which this amendment now relieves them, and $8,000,000 in Federal aid, making a total of $51,000,000 to be expended on the State system within the next few years.

The State voted in 1910 for a bond issue of $18,000,000 for two trunk roads, covering about 3,000 miles. This amount was not sufficient to do the work, and in 1916 $12,000,000 additional for the State system and $3,000,000 as one-third of $9,000,000 for laterals to be completed by counties were voted. The amount now made available and that already expended makes a total of $81,000,000 provided for the State highway system in 10 years. In addition to this amount counties have raised many million dollars for other roads. The amount voted by counties this year will be almost as great, in the aggregate, as the new State bond issue.

FOR IDAHO ROADS.

Ada County, Idaho, will vote on a road bond issue of $1,000,000. If the proposition carries the funds are to be used for nothing but hard-surfaced roads. It is believed this amount will be sufficient to complete the good-roads system throughout the county. Fremont County, that State, has voted in favor of a bond issue of $400,000. Three additional road districts in Latah County have voted $420,000, bringing the total amount voted in that county to $1,125,000. Other proposed bond elections are in Washington County for $200,000 and in the Nampa road district for $500,000. Teton County has voted on an issue of $100,000.

BOND ROADS IN MONTANA.

Five Montana counties have this year voted for issuing bonds for road building. They are: Gallatin, $400,000; Yellowstone, $75,000; Meagher, $150,000; Sweetgrass, $100,000; and Park, $150,000. In September special elections will be held in 31 counties. If all should cast a favorable vote, there will be a total of $6,688,000 in highway bonds voted by Montana counties this year. The largest proposed issue is that of Fergus County, $700,000. Cascade County will vote on an issue of $500,000; Custer, on one of $350,000; Fallon, $275,000; Yellowstone, Missoula, and Silver Bow on $250,000. Other amounts run from $35,000 to $200,000.

A YEAR'S ROAD RECORD.

The State highway department of Pennsylvania is making a great record this year in pushing highway construction. The State highway commissioner has advertised for bids to be opened August 5 for the construction of 60½ miles of roads located in various parts of the State and will soon advertise for bids for 74.7 additional miles. These will bring the total mileage of roads for which contracts have been let or for which they have been advertised this season up to 675.7 miles. This is said to be the best known record in such work, but the commissioner will continue to let contracts throughout August and September.

Contracts let up to July 24 include 452.25 miles of the primary highway system, for $16,020,924.70, 10.89 miles of the secondary road system at a cost of $468,500.29, and 7.33 miles of State-aid roads not on the State highway system at a cost of $259,810. The total contracts awarded call for 470.45 miles at the low-bid-price of $16,749,235.34. A recent inspection showed that on 59 contracts the construction on 52 was up to or above par in the progress made by the contractor.

On August 18 bids will be opened for the construction of 66 concrete bridges.

$2,500,000 BONDS FOR PAVING.

Woodbury County, Iowa, of which Sioux City is the seat, voted July 7 by about 4 to 1, in favor of a highway bond issue of $2,500,000. Only two townships voted against the issue, while in Sioux City the vote was nearly 13 to 1. The county has 125 miles in its primary system of roads which has been approved by the State highway commission. The larger part of this system has been graded and drained, and is practically ready for the paving to be laid from the proceeds of this bond issue. Plans have been made so the work can start with practically no delay.

SPOKANE VOTES $3,250,000.

By a vote of 6,984 to 3,366 Spokane County, Wash., approved the proposed issue of road bonds to the amount of $3,250,000. It is estimated that 300 miles of new road will be built. The first $450,000 of the bonds will probably be sold about January 1, so that work on the system can start in the spring. The projects will be grouped. A construction engineer will be employed, and he and the county board of supervisors will decide upon the most important improvements and the order of construction. The townships must bind themselves to furnish 15 per cent of the cost of a road.

ROAD BUILDING IN THE SOUTHWEST

By M. O. ELDRIDGE, Assistant in Road Economics.

THE Federal aid road act has had the effect of stimulating road building throughout the length and breadth of the country. There is no section of the country, however, where road building is now being carried on with more vigor, if considered from the standpoint of wealth and population, than in the semiarid and irrigated regions of the great Southwest. This statement is based on observations made on a recent trip of inspection over a proposed link in a southern transcontinental highway extending from El Paso, Tex., to San Diego, Calif. This road is known as the Bankhead Highway and extends from Washington through the Southern States to the Pacific coast, the road having already been designated as far west as El Paso.

Unusual road activity in the Southwest is indicated by the fact that the State of Texas is planning to issue $75,000,000 of road improvement bonds with which to meet Federal aid and cooperate with the counties in building a system of State highways. Between January 1 and June 1, 1919, Texas counties voted $63,667,000 of road improvement bonds. California voted a $40,000,000 bond issue with which to complete its State system, that State having already voted and expended $33,000,000 for the same purpose. Numerous counties in Texas, New Mexico, Arizona, and California have provided large sums of money with which to meet State and Federal assistance. Maricopa County, Ariz., for instance, recently voted $4,000,000 with which to complete a system of country roads, and Fresno County, Calif., $4,800,000.

INFLUENCE OF FEDERAL AID.

The influence of the Federal aid road act is further shown throughout this section of the country by the fact that States and counties, almost without exception, are providing themselves with competent engineering help under whose direction these large sums of money will be expended. There is every reason to believe that within the next few years the more important roads in this whole region will be improved, as well as the missing links on the great transcontinental highway above referred to, among which should be mentioned the road across the Monahan sands of Ward County, Tex., the almost impassable sections of road across the silt flats between Phoenix and Yuma, and the sand hills between Yuma and El Centro in California.

El Paso County, Tex., has already completed her section of the transcontinental highway. From El Paso to the Hudspeth County line on the east the road is composed of bituminous concrete. It is about 18 feet wide and is planted on both sides with cottonwoods which make the road very picturesque and pleasing to those who use it. From El Paso on north to the New Mexico line the road is paved to a width of about 18 feet with concrete. These two sections of road rank with the best pieces of road on the entire route from the Atlantic to the Pacific.

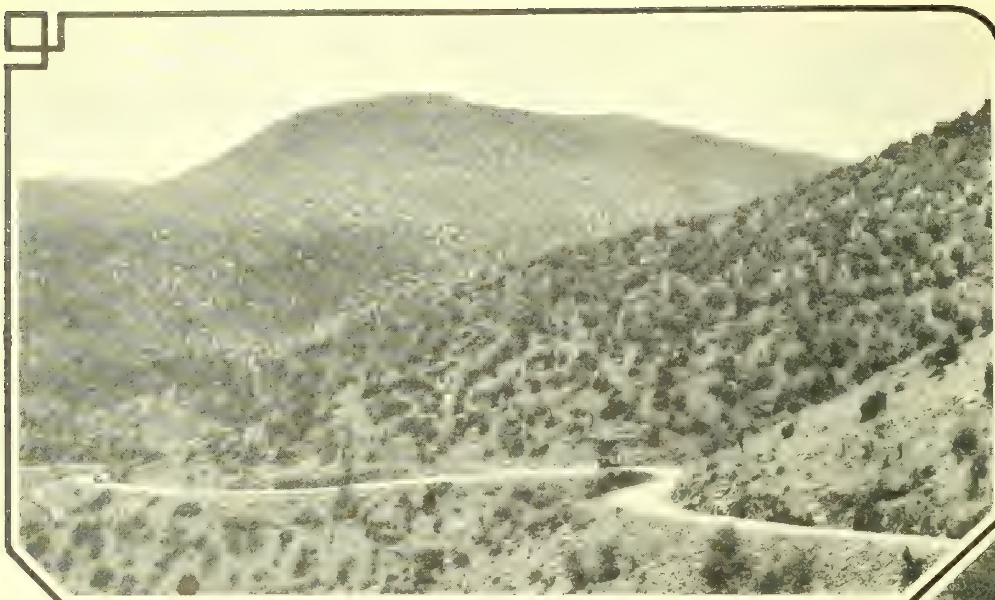
The roads through New Mexico consist largely of natural roads over a desert country through the desert growth of chaparral, greasewood, and mesquite. The soil for the most part contains sand or gravel and the roads are fair except in the low places where they cross adobe flats. Even in the adobe flats the roads, although rough, are fairly good for the light traffic to which they are subjected except in the rainy season. On several sections of the route in New Mexico, notably near Deming and Las Cruces, the roads have been graded and drained, drainage structures provided, and the roads surfaced with gravel. Many miles of these roads appear to be entirely satisfactory for present traffic needs.

CONVICTS BUILD A ROAD.

Under the direction of the County Road Commission, Cochise County, Ariz., is expending about $1,000,000 on the improvement of its most important roads with gravel and concrete. Between Douglas and Bisbee a concrete road is now under construction. Between Bisbee and Tombstone a road was completed last year with convict labor by the State Highway Department of Arizona, which is now in first class condition. This is a splendid piece of mountain road construction. The road is surfaced with disintegrated granite and is kept in splendid condition by dragging. The county road between Douglas and Benson is now being completed by the county road commission of Cochise County.

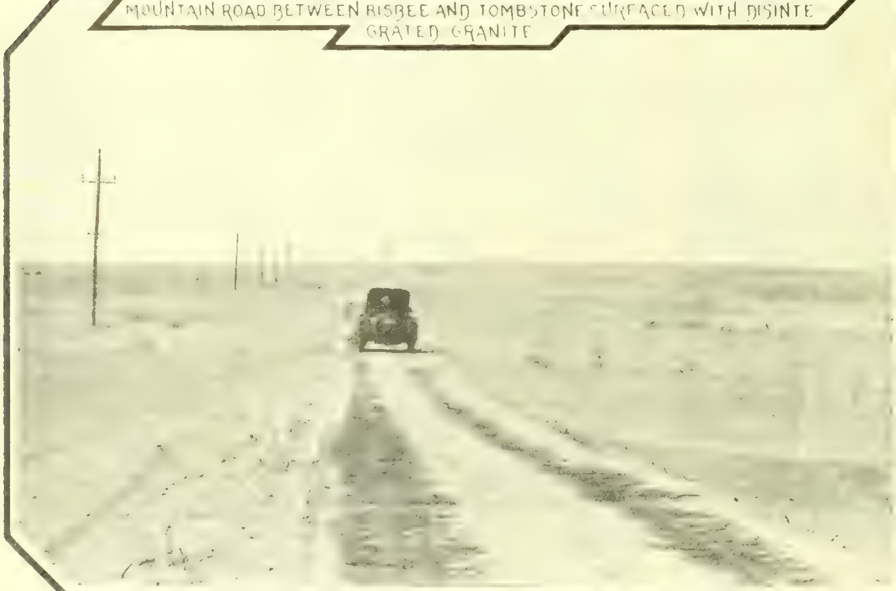
One of the best and cheapest pieces of gravel road construction found on the various routes in Arizona was between Vail and Tucson, in Pima County. This road cost less than $1,000 a mile, due to the fact that the mesa over which it is constructed is composed of a gravel formation. The work of construction consisted principally in clearing away the greasewood, cactus, and other desert growth, paving the dips, grading the road surface, and providing proper ditches.

To the casual observer ditches, culverts, and bridges would not be needed in the arid regions of the Southwest, but it is found that during the rainy season the water comes down in torrents and that when the friable soil is thoroughly saturated drainage structures are just as necessary as in the Eastern States. In fact, one of the principal problems of the road building in the Southwest consists in protecting



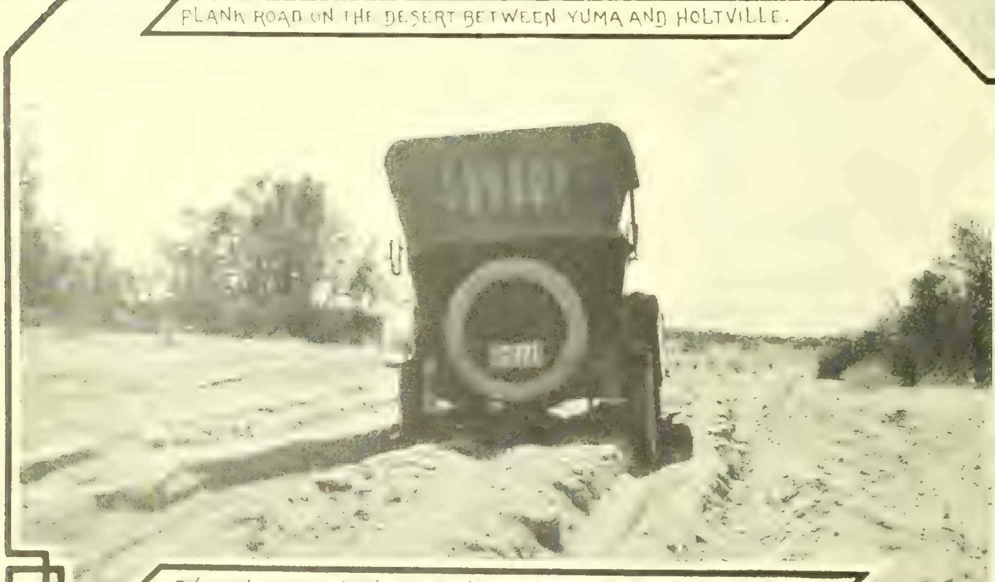
MOUNTAIN ROAD BETWEEN BISBEE AND TOMBSTONE SURFACED WITH DISINTEGRATED GRANITE

STATE HIGHW



PLANK ROAD ON THE DESERT BETWEEN YUMA AND HOLTVILLE.

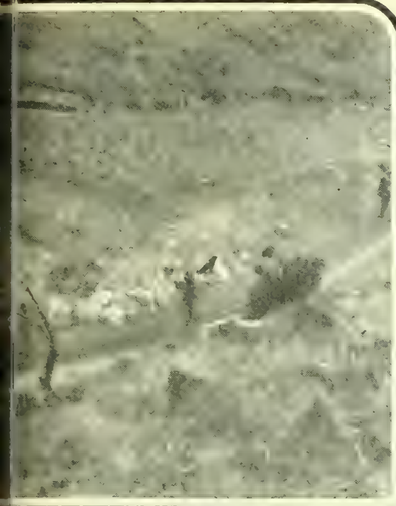
TYPICAL GILA VALLEY ROAD NEAR SOLO



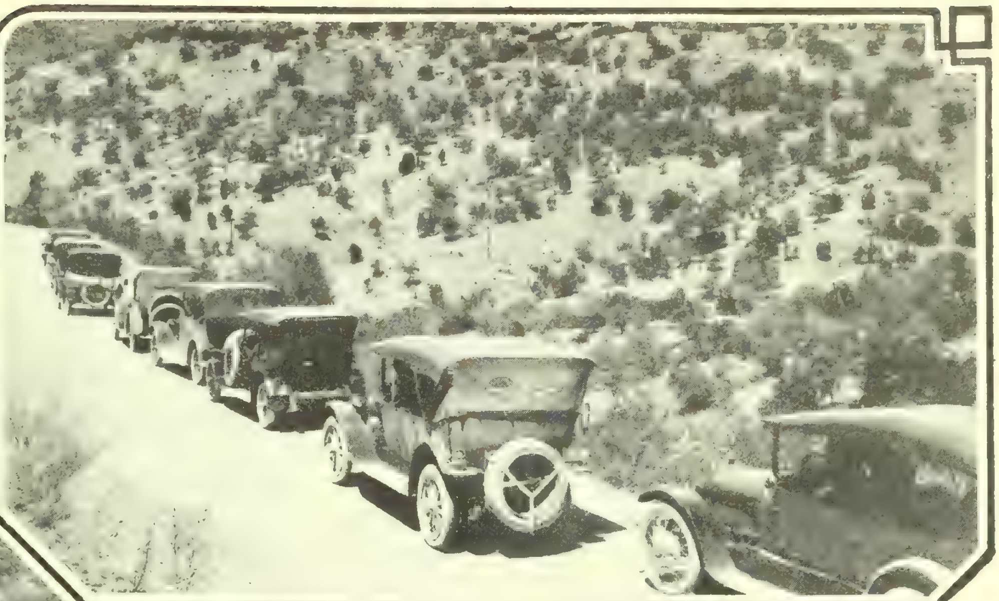
TYPICAL ROAD ALONG THE GILA RIVER NEAR AGUA CALIENTE.

CONCRETE BRIDGE

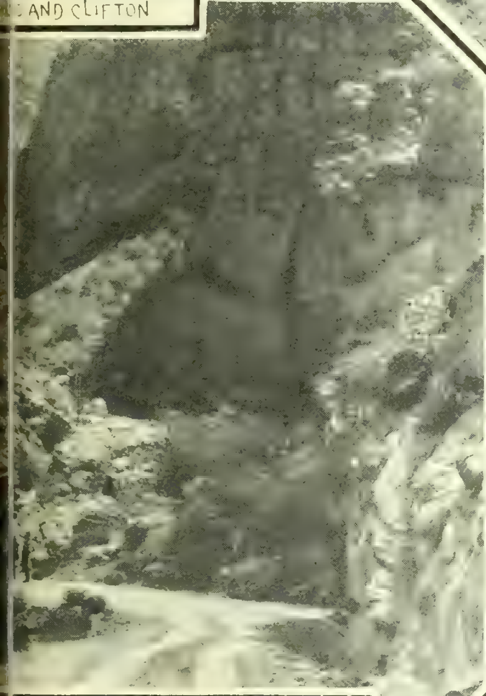
ON THE HIGHWA



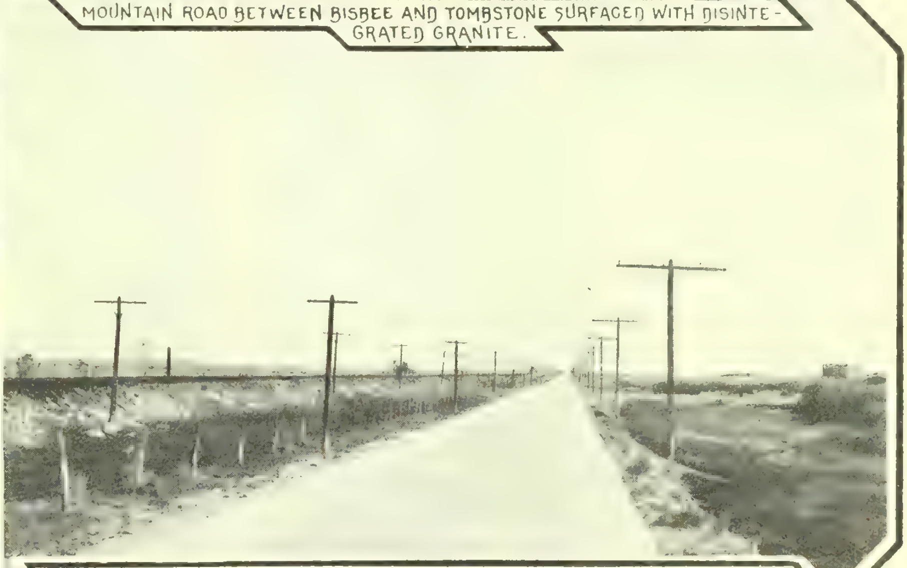
AND CLIFTON



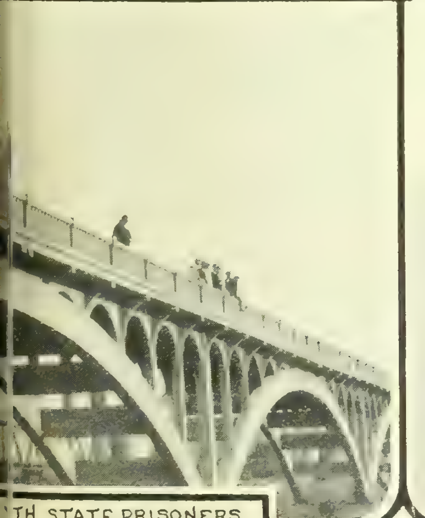
MOUNTAIN ROAD BETWEEN BISBEE AND TOMBSTONE SURFACED WITH DISINTEGRATED GRANITE.



HE ROAD BETWEEN TEMP AND
ROSEVELT DAM, APACHE TRAIL.
FOOT OF FISH CREEK HILL.



CONCRETE ROAD NORTH OF EL PASO NEAR NEW MEXICO LINE



TH STATE PRISONERS.

STUCK IN DESERT SANDS BETWEEN YUMA AND HOLTVILLE the road from erosion, due to the quick rise of water in the stream beds during the rainy season, or to the flow of water down the naked slopes of mountains and mesas.

AVOIDING USE OF CULVERTS.

Instead of constructing culverts and bridges in the usual way the practice has developed during the few years in the Southwest of paving or providing curbs on both sides of improved roads where the roads cross dry stream beds locally known as "arroyas." These paved fords or dips permit the flood waters to flow across the road surface without causing erosion. It is found that the construction of these dips is much less expensive than the construction of culverts and bridges and that they are just as satisfactory, except where they cross the the larger stream beds.

Another problem which confronts the road builders of the arid regions is the building of roads across the adobe flats and where the soil is composed of fine silt loam. If the roads across these flats are used much in dry weather, the soil pulverizes into dust, and the roads become full of dust holes in which vehicles often sink to the axles. In the rainy season these same places develop into mudholes which render the road almost impassable. The road between Phoenix and Yuma, along the Gila River near Agua Caliente, contains many places similar to those described.

One of the most picturesque highways in Arizona is the road known as "The Roosevelt Road," or "The Apache Trail," which extends from Phoenix to Globe via Roosevelt Dam, thence to Clifton through Solomonville. The section of this road from Masa to Roosevelt was built by the United States Government as a wagon road over which to haul cement to the dam site before the cement plant was constructed. It is not at present well suited to automobile or tourist traffic as many of the grades are rough, narrow, and dangerous and the surface is poorly maintained.

SAND BURIES DESERT ROAD.

From Roosevelt to Globe the road is at present all that could be desired. Through the Gila Valley, from Globe to Solomonville, and on toward Clifton, there are many stretches of excellent gravel road. There is also a good section of gravel road over the mountain into Clifton built by convict labor under the direction of the State highway department. Aside from a few adverse grades this is a fine piece of mountain road building. Between Clifton and Lordsburg, N. Mex., the road extends across several mesas through a beautiful rolling country covered with typical desert growth. The road is composed largely of gravelly soil.

To the ordinary road traveler the trip from Yuma, Ariz., to Holtville, Calif., across the desert sands and sand dunes involves many hazards. These dunes vary in height from 10 to 20 feet, and are constantly shifting. A road built over or through them would be covered with sand within a few days, sometimes within a few hours. A few years ago several miles of plank road were built across these dunes, but several workmen and teams have to be constantly employed in removing the sand in order that the road may remain open. These sands could be avoided by building the road around them to the north, but such a road between Yuma and Holtville would be about 50 miles longer than directly across the sands.

It is understood that the State of California has provided that this road is to be improved, with funds derived from the proposed bond issue, thus connecting Yuma with the coast at San Diego by a hard-surfaced road. It is also understood that the plan proposed for crossing the sands will be to build a bridge from 20 to 30 feet high over the sands, open underneath so as to permit the circulation of air and sand.

IRRIGATING EARTH ROADS.

The natural earth roads in the Imperial Valley in southern California become very dusty in the dry season and very heavy in the wet season if subjected to heavy or fast traffic. During the past few years a practice has grown up in the valley of irrigating the roads. For this purpose the road is laid out in sufficient width for two separate and distinct driveways with a ridge of earth between. Instead of crowning the road as in a humid country the surface is made to slope slightly toward the center and is slightly below the surface of the irrigation ditches which usually parallel the road on both sides. About every two weeks during the dry season one side of the road is irrigated. When the surface begins to dry it is dragged. During this process the other side of the road is being used by traffic. As soon as the irrigated section is dried out sufficiently, traffic is turned on and the other side of the road is then irrigated. This method of maintenance produces a comparatively hard and dustless surface and has proven very satisfactory. The roads are usually planted on both sides with poplars, cottonwood, and eucalyptus and are very beautiful and pleasant to rive over.

Between Holtville and San Diego through Imperial and San Diego Counties the State of California has either completed or has arranged for the completion of a paved highway 16 to 18 feet in width. The scenery along this road through the coast range mountains is particularly beautiful. The State road through El Cajon Valley in San Diego County deserves special mention. The road is paved with a durable surface to a width of about 18 feet and excellent taste has been displayed in the planning and planting of the roadsides.

JUNE A RECORD-BREAKING MONTH FOR FEDERAL-AID ALLOTMENTS

IN June the record of Federal-aid statements approved surpassed that of all previous months in the numbers of projects, the mileage involved, the estimated cost of the roads to be built and the amount of Federal aid allowed. This is also true in regard to the record of the project statements for which agreements were signed by the Secretary of Agriculture. Since early in the year there has been a steady increase each month in the Federal-aid business in the Bureau of Public Roads. States in all sections of the country are filing their projects and receiving allotments. The road-building era is in full swing, and it would seem that the end is not yet. All indications point to yet greater records in the months immediately to come.

The table of Federal-aid projects considered during June in this issue of Public Roads lists 239 projects. New statements approved were 133, while there were revisions of 4 statements previously approved. Sixty agreements were executed, 41 previously executed were modified and 1 was cancelled, the road being provided for in a modification of another project.

The statements approved during the month were for 1,426.84 miles of road, estimated to cost $25,611,314.99, with a Federal-aid allowance of $11,725,500.61. These are increases over the May figures of 663.897 miles, $10,407,436.93 in the estimated cost and $5,297,082.82 in the amount of Federal aid.

Agreements signed by the Secretary of Agriculture called for Federal aid amounting to $4,376,743.98, with an estimated cost of $7,566,089.32.

The June statements approved bring the total amount of Federal aid applied for up to $54,654,984.44, almost $5,000,000 in excess of the amount which would have been available up to the close of the fiscal year 1920 under the original Federal aid law.

BIG ILLINOIS PROJECTS.

Two new projects from Illinois set a new record. No. 8 for 86 miles of road, is estimated to cost $2,321,650.00, and No. 9 for 150 miles of road, is estimated to cost $4,463,511.60. Although project No. 8 does not break previous records for length of a single project, it does break the previous record for total cost, and project No. 9 breaks the previous records both for length and cost.

Project No. 8 involving the construction of the East St. Louis-Springfield Highway in southwest Illinois, begins at the north city limits of Granite City in Madison County, and extends northward through the counties of Madison and Macoupin to the south city limits of Springfield in Sangamon County. It is an important link in the $60,000,000 State highway system and a portion of the main highway connecting St. Louis and Chicago. The general topography of the country is level or slightly rolling and is well developed farming land. The present road surface is unimproved earth which becomes nearly impassable at certain seasons of the year. During the winter months there is practically no through traffic. During the summer months the average daily through traffic is approximately 5 trucks and 100 passenger motor vehicles. Local traffic will vary according to the proximity of the section to the different towns along the project, but for the entire road the average daily is approximately 30 trucks, 200 passenger motor vehicles, and 60 horse-drawn vehicles. When the road is improved the figures for motor traffic will be more than doubled.

No material is available for surfacing along the entire road and all such material will have to be obtained from commercial sources and shipped by rail to points along the project. The type of surfacing is to be monolithic brick from Granite City to Mitchell and concrete pavement for the remainder of the distance. The average cost per mile for the project is approximately $27,000.

COMPLETING THE OLD NATIONAL ROAD.

Project No. 9, which will undoubtedly hold the record for length and cost for some time to come, is of unusual interest aside from its great length and cost. It contemplates, after the lapse of nearly a century, the completion of the Old National Road, extending from the Potomac to the Mississippi, which already has been largely improved as far west as the Indiana line. The Illinois improvement will extend from East St. Louis across the State to the Indiana line, traversing St. Clair, Madison, Bond, Fayette, Effingham, Cumberland, and Clark Counties.

The proposed type of surface is monolithic brick and concrete pavement, the average cost of which is about $30,000 per mile. The proposed improvement includes also the construction of 40 bridge structures of lengths ranging from 22 feet to 300 feet. At present the highway is generally an unimproved earth road which becomes nearly impassable at certain seasons of the year. There are, however, near some of the villages short stretches of macadam pavement, generally in very poor condition. The local traffic consists of approximately 60 trucks, 700 motor vehicles, and 50 horse-drawn vehicles per day, to which is added during the summer months a through traffic of about 20 trucks, and 200 passenger motor vehicles.

More than a century ago after a lengthy debate and a hard fight, Albert Gallatin, ably seconded by Henry Clay, succeeded in getting an act passed and approved by President Jefferson on March 29, 1806, appropriating $30,000 for the survey and construction of a National Road leading from the Potomac at Cumberland, Md., to the Ohio River opposite Steubenville. This famous highway was finished as far as Wheeling, a distance of 132 miles in 1820, although coaches carrying Government mail started using the road on August 1, 1818.

THE FIRST HIGHWAY.

The highway was cleared for a width of 80 feet and surfaced with broken stone 20 feet wide, 18 inches thick at the center and 12 inches thick at the edges. The upper 6 inches of stone was broken to pass through a 3-inch ring and the bottom course stone was of a size that would pass a 7-inch ring. The filling and binding material was mostly gravel and the whole compacted with a 3-ton iron faced roller 4 feet in length. Earth shoulders 6 feet wide were provided on each side of the broken stone, making the available travel way 32 feet. The maximum grade was 5°, or as usually expressed by modern highway engineers, about 8.7 per cent.

On May 15, 1820, an act of Congress provided $10,000 for laying out the plans of the road from Wheeling to the Mississippi by way of Columbus, Indianapolis, and Terre Haute to St. Louis. Indianapolis at that time contained about 150 houses, mostly of logs, and a courthouse, a jail, and three churches. The Mississippi River then represented practically the extreme western boundry of our inhabited area, as beyond that line, except in Louisiana and Missouri, not over 30,000 inhabitants were to be found. This new section of the National Road was surfaced from Wheeling as far as Columbus and construction had progressed as far west as Illinois when the development of the steam railroad as a transportation agency in 1838 put an end to further work and the entire road was taken over and operated by the various States as a toll road. When it is realized that freight charges over the National Road from Wheeling to Baltimore were $45 per ton, it is readily understood how the newly completed Baltimore & Ohio Railroad could so completely destroy the usefulness of the highway as a means of transporting freight. The work had been progressing for 32 years, and although it was to have been built by the Government out of funds derived from the sale of public lands in the States through which it passed, it was found necessary for the Government to contribute about $7,000,000 for construction purposes between 1806 and 1838.

EARLY DAY TRAFFIC.

The following interesting account of the stage coach activity on the Old National Road is found in Ringwalt's Development of Transportation Systems in the United States: "At various times four companies engaged in staging. They were the National Line, Good Fortune, June Bug, and The Pioneer stage lines. Relays were established at a distance of from 10 to 12 miles and there are some records of quick changing that would make a modern Gehu turn green with envy. An old driver still boasts of harnessing his four horses in four minutes and of changing teams before the stage ceased rocking. Ponderous trunks were strictly forbidden, each passenger being limited to 50 pounds baggage and there was careful weighing in those days. Each stage complement consisted in not more than nine passengers. As many as 14 coaches have traveled together with their one hundred-odd passengers.

"In those days the mail coaches left Wheeling at 6 a. m. and just 24 hours later dashed into Cumberland, having traversed a distance of 132 miles. Occasionally there were delays, but these were not permitted upon the completion of the Baltimore & Ohio Railroad to Cumberland. * * * At that date most of the freight for the West was conveyed from Baltimore and Frederick to Wheeling and points in the West with the old Conestoga wagons which, together with the numerous droves of cattle, sheep, and hogs driven to market, frequently caused great obstruction to the stage coaches in getting by and through them.

"In 1846 when the Baltimore & Ohio Railroad reached Cumberland the travel over the National Road was greatly increased. Competitive stage lines were put on and it was no unusual thing to see from 15 to 20 coaches leave and enter Cumberland twice a day. The great stream of travel between the East and West poured over the National Road from that time on for several years. In 1852 the Baltimore & Ohio Railroad reached the Ohio River and it remained for the son of the father who started the first line of stage coaches across the Allegheny Mountains with the daily mail to carry the last mail for the East by coach."

INDIANA BEGINS BIG PROGRAM.

Indiana makes its appearance in the list of project statements approved in June. Indiana, as did other States, passed a law to enable that State to take advantage of the Federal aid act soon after it was placed on the statute books. In the first year of the operation of the law a half dozen or more Indiana applications were made for Federal aid. They were held up by an attack on the Indiana law in the courts of that State. It was not until last winter that final decision in the case was rendered by the Indiana Supreme Court, upholding the constitutionality of the law. In the meantime, however, a bill had been introduced into the legislature of 1919 for a new highway law, which was afterwards passed. Under this new law the State highway commission was reorganized and a road program was later adopted. Now Indiana is prepared to go forward in harmony with other States in rapid highway building in cooperation with the Federal aid law.

The first evidence of this fact was in June, when six project statements were submitted to the Bureau of Public Roads which were approved before the end of the month. The six projects cover 113.6 miles of road and their estimated cost aggregates $4,585,238.88. This is an average of over $40,374 a mile. All these roads are to be of brick, concrete or bituminous concrete.

Two of the projects are very large ones, among the largest projects so far submitted from any State. The larger of the two is for 35.3 miles of road in Hancock and Henry Counties, and has an estimated cost of $1,419,928, or about $40,225 a mile. The other is for 35.1 miles in Vigo, Clay, and Putnam Counties and its estimated cost is $1,394,016.80, or $39,713 a mile. This is a revision of a project approved nearly two years ago. In the table only the increased figures are given. These two projects are for stretches of the Old National Road in Indiana, the former lying between Indianapolis and Richmond and the latter between Terre Haute and Indianapolis. A third project for a stretch of this road submitted is for 14.7 miles between Terre Haute and Indianapolis, in Hendricks County, estimated to cost $610,606. These three projects will practically carry the rebuilding of the Old National Road across Indiana, and with the big Illinois project will about complete the reconstruction of that road from St. Louis to the Ohio-Indiana boundary line.

Two of the other Indiana projects filed in June are for stretches on the Lincoln Highway in Elkhart and St. Joseph Counties. One of these will cost $46,790 a mile. The remaining one is a part of the Michigan road, in Marshall and St. Joseph Counties, a north and south highway. All the projects are portions of the established State highway system of the State, to be built and maintained by the State highway commission. The funds for building and maintaining State highways are provided by a tax of 10 cents on the $100 of property valuation, fees from motor and chauffeurs licenses and from inheritance taxes.

FEATURES OF THE MONTH.

The two Illinois projects approved in June together call for Federal aid to the amount of $3,392,580.80, with an estimated cost of $6,785,161.60 for 236.70 miles of brick and concrete roads.

Indiana's record for the month comes next to that of Illinois, in the amount of Federal aid allowance and in the estimated cost of the projects. The Federal aid allowance for Ohio projects amounts to $1,120,350 on an estimated cost of $3,265,154. Pennsylvania projects are estimated to cost $2,077,903.08, with Federal aid of $913,374.85, while West Virginia comes to the front with a number of important projects, estimated to cost $1,248,841.84, for which the Federal aid allowance is $691,791.36.

In the number of projects approved Nebraska leads with 19 and the mileage of these projects, 385.31, also puts that State at the top of the list in the length of roads to be improved. Ohio had 17 projects approved, with a total length of 92.65 miles. New Hampshire comes third in the number of approvals, 16, but all of them together have a mileage of only 18.09 miles.

In agreements executed during the month Pennsylvania leads in number with 6 originals and 14 modifications and Iowa in mileage, 71.69. Pennsylvania will receive $1,170,958.85 of Federal aid for projects which will cost $2,053,471.20. New York follows in the estimated cost of roads and in the Federal aid allowance for agreements signed, while Ohio is third. The New York roads will cost $1,187,364, with Federal aid of $586,932.17. The Ohio roads will receive Federal aid amounting to $360,674.52, on an estimated cost of $1,028,565.72.

Of the 1,426.8 miles of road covered by the statements approved during the month nearly one-half are to be either concrete, brick, bituminous, or bituminous macadam.

One Ohio project, 6.6 miles long, will cost an average of $65,909 a mile. Other high cost roads are 7.08 miles in New York to be built at an average of $60,464, and 16.6 miles in Kansas, the cost of which will average $55,473.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	11	Lowndes		Gravel	June 16		[1] 6,466.29	[1] 3,249.49
	13	Calhoun		Chert		June 19	[2] 10,032.00	[2] 5,016.00
	55	Jefferson	5.00	Asphalt, brick, or concrete	June 30		174,295.55	87,147.77
	56	do	3.83	do	do		138,874.45	69,437.22
	57	do	6.00	do	do		220,184.80	110,092.40
Arkansas	21	St. Francis	7.93	Gravel		June 19	34,333.72	15,000.00
California	8A	Trinity	11.40	Graded and drained earth		June 2	310,984.30	155,492.15
	10	Modoc	10.85	Graded earth		do	78,717.65	39,358.82
	19	Mendocino	9.74	Earth	June 7		116,424.00	58,212.00
	20	Lake	9.36	do	June 5		116,798.00	58,399.00
Colorado	17	El Paso	2.27	Earth and sand-clay	June 7		31,075.00	15,537.50
Delaware	4	Sussex	4.39	Concrete		June 19	168,408.60	84,204.30
Georgia	23	Forsyth	11.20	Sand-clay	June 18		52,266.50	25,000.00
	54	Floyd	2.80	Concrete	June 7		96,332.39	48,166.19
	68	Walton	9.00	Sand-clay	June 3		69,982.00	34,991.00
	74	Sumter		3 bridges	June 2		17,352.50	8,676.25
Illinois	8	Madison, Macoupin Sangamon	86.20	Brick and concrete	June 30		2,321,650.00	1,160,825.00
	9	St. Clair, Madison, Bond, Fayette, Effingham, Cumberland, and Clark.	155.50	do	June 26		4,463,511.60	2,231,755.80
Indiana	1	Elkhart	[1] 1.50	Brick, concrete, or bituminous concrete	June 20		[1] 81,488.00	[1] 59,444.00
	6	Vigo, Clay, and Putnam	[1] 28.85	do	June 19		[1] 1,286,496.80	[1] 619,500.00
	10	Marshall, St. Joseph	19.00	do	June 18		769,032.00	380,000.00
	11	St. Joseph, Elkhart	3.50	do	do		163,768.00	70,000.00
	13	Hancock, Henry	35.30	do	June 30		1,419,928.00	709,964.00
	15	Hendricks	14.70	do	do		610,606.00	305,303.00
Iowa	3	Jefferson	[2] .75	Graded earth		June 21	[2] 16,603.13	[2] 18,169.45
	9	Johnson	10.89	Brick, concrete, and earth		June 7	79,889.54	23,859.55
	16	Montgomery	15.93	Earth		do	95,469.97	45,000.00
	22	Linn	18.00	Brick, concrete, gravel, and earth		June 23	189,979.97	27,718.86
	25	Black Hawk	4.05	Brick, asphalt, or concrete		June 19	168,412.04	46,881.28
	28	Sioux	24.25	Earth	June 9		65,780.00	29,381.20
	31	Howard	10.40	Gravel		June 9	55,517.44	27,000.00
	35	Chickasaw	13.17	do		June 12	85,292.54	42,000.00
	38	Plymouth	27.85	Earth	June 16		71,621.00	33,285.80
	44	Cass	19.60	do	June 3		75,856.00	21,804.00
Kansas	28	Ford	16.60	Brick or concrete	June 19		920,856.20	249,000.00
Kentucky	1	Boyd		do		June 27	[2] 53,612.22	[2] 53,781.94
	4	Carter	[2] .01	Earth		do	[2] 21,415.83	[2] 10,707.91
	5	Mercer		Macadam		do	[2] 16,804.87	[2] 8,402.4
Louisiana	22	Rapides	1.66	Bituminous macadam		June 4	67,845.63	33,922.81
	28	Iberia		Gravel		June 12	[2] 14,827.97	[2] 8,541.59
	31	Avoyelles		do		June 26	[2] 4,345.18	[2] 2,172.59
	32	Grant	20.23	do	June 19		214,629.58	107,314.79
	35	Jefferson Davis	7.50	Sand-clay and gravel	June 7		64,589.66	32,294.83
	36	Tangipahoe	12.56	Gravel	June 23		110,777.75	55,388.87
Maine	4	Penobscot	7.05	do	June 5		108,765.80	54,382.90
Massachusetts	21	Berkshire	3.645	Concrete	June 23		148,401.00	72,900.00
Maryland	6B	Prince Georges, Howard, Baltimore.	11.60	do		June 21	191,554.89	95,777.45
	11	Frederick	1.86	do		June 9	71,596.91	35,798.45
	13	Prince Georges	1.67	do		do	61,670.54	30,835.27
	19	Wicomico	1.53	do		June 21	54,691.01	27,345.50
	21	Kent	3.02	do		do	83,953.16	41,976.58
	23	Caroline	.65	do		June 9	19,795.01	9,897.50
Michigan	16A	Washtenaw		Concrete, asphaltic concrete, or brick		June 17		9,527.30
	30	Cass	7.095	Concrete or bituminous		June 19	189,496.07	94,748.03
	31	Berrien and Van Buren	6.718	do		June 4	198,911.70	99,455.85
Minnesota	6	Carver		Graded and drained earth		June 26	[2] 50,146.59	[2] 20,000.00
	14	do		Gravel		do	(3)	(3)
	37	Hennepin	5.50	Asphalt, brick, or concrete	June 30		197,627.10	40,000.00
	45	Nobles	19.95	Gravel	June 18		114,620.00	57,310.00
	47	Pope	16.50	do	do		74,475.53	37,237.76
	48	Swift	12.15	Pavement and gravel	June 20		261,646.00	120,000.00
	50	Mahnomen	4.00	Gravel	June 13		15,158.00	7,579.00
	58	Nobles	5.50	Concrete, brick, or asphalt	June 19		138,050.00	60,000.00
	59	Becker	3.80	Gravel	June 4		18,162.32	9,081.16
	61	Freeborn	14.70	do	June 20		85,716.40	42,858.20
	62	Dodge	5.75	do	June 18		32,736.16	16,368.08
Mississippi	22	Benton	11.82	do		June 20	109,358.03	54,679.01
	24	Marshall	6.98	do		June 4	39,325.00	10,000.00
Missouri	8	Harrison	9.39	Concrete and macadam		June 23	165,299.38	82,649.69
	9	Jefferson	9.39	Gravel and macadam		June 25	46,934.51	23,467.26
Montana	33	Musselshell	4.25	Earth and gravel	June 24		21,547.68	10,773.84
	40	Gallatin	2.75	Gravel and macadam	June 26		18,393.92	9,196.96
	41	do	5.00	do	June 30		30,140.00	15,070.00
Nebraska	18	Gage and Lancaster	36.96	Earth		June 23	113,978.57	56,989.28
	20	Lancaster	[1] 6.20	do	June 3		[1] 17,050.00	[1] 8,525.00
	21	Douglas		do		June 23	[2] 5,588.22	[2] 2,794.11
	30	Furnas	21.50	do	June 16		32,554.50	16,277.25
	31	Dixon	16.93	do		June 23	60,689.07	30,334.53
	34	Garfield	9.76	Earth and sand-clay	June 16		16,142.50	8,071.25
	44	Sherman	3.50	Earth	June 6		8,085.00	4,042.50
	46	Red Willow	17.20	do	June 3		52,800.00	26,400.00
	50	Merrick and Nance	29.60	do	June 16		59,620.00	29,810.00
	53	Boone and Nance	21.60	do		June 4	69,375.74	34,687.87
	58	Colfax	18.35	do	June 16		26,730.00	13,365.00
	63	Hayes and Perkins	41.50	do	June 4		77,000.00	38,500.00
	65	Greeley	18.50	do	June 23		45,320.00	22,660.00
	67	Furnas and Red Willow	39.50	do	June 20		85,800.00	42,900.00
	72	Cedar	22.00	do	June 3		46,750.00	23,375.00
	75	Fillmore and Thayer	19.30	do	June 16		44,792.00	22,396.00
	77	Adams	11.50	do	June 2		24,640.00	12,320.00
	78	Douglas	13.00	do	June 16		33,000.00	16,500.00
	82	Garden and Morrill	32.10	Earth and sand-clay	June 30		72,270.00	36,135.00
	86	Butler and Polk	17.00	Earth, gravel, and concrete	June 23		64,735.00	32,367.50
	91	Douglas and Washington	16.50	Earth	June 5		48,400.00	24,200.00
	92	Buffalo and Sherman	15.00	do	June 30		44,440.00	22,220.00
	98	Saline and Lancaster	33.30	do	do		72,600.00	36,300.00

[1] Revisions of project statements previously approved. Figures given are increases over amounts in original statements.

[2] Modified agreements. Amounts given are increases over those in original agreements.

[3] Canceled.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919—Continued.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Nevada	7	Washoe		Gravel and macadam		June 23	[1] 203,840.34	[1] 101,920.00
	14	Douglas	3.45	Gravel		June 4	26,847.70	13,423.85
	15	Elko	8.34	Earth		June 2	42,269.15	21,134.57
	23	Mineral	10.00	do	June 2		148,060.00	74,030.00
New Hampshire	8	Sullivan		Telford base with asphalt surface		June 26	[1] 7,041.08	[1] 3,520.54
	28	Grafton and Merrimack	1.10	Gravel	June 23		14,808.20	7,404.10
	29	Merrimack	.49	do	do		5,974.43	2,987.21
	30	Grafton	.38	do	do		5,192.22	2,596.11
	31	do	.46	do	do		5,382.19	2,691.09
	36	Cheshire	1.34	do	June 18		12,549.02	6,495.39
	39	Grafton	.73	do	June 23		9,983.27	4,991.63
	40	Merrimack	1.25	do	June 16		9,082.48	4,541.24
	41	do	1.25	do	do		9,900.00	4,950.00
	42	Stafford	1.50	do	June 23		12,549.02	6,495.39
	43	Rockingham	1.26	do	do		10,063.84	5,031.92
	44	Cheshire	.348	Bituminous	June 24		13,297.77	6,648.88
	49	Belknap	1.25	Gravel	June 30		9,900.00	4,950.00
	50	Cheshire	1.25	Bituminous macadam	do		19,929.47	9,964.73
	51	do	.86	Bituminous	June 23		15,708.02	7,854.01
	53	Grafton	3.62	Gravel	do		45,206.43	22,603.21
	59	Cheshire	1.00	Macadam	do		19,321.28	9,660.64
New Mexico	20	Lincoln	7.00	Gravel	June 30		59,061.20	29,530.60
New York	1	Chautauqua	4.64	Concrete		June 26	144,956.35	72,478.17
	3	Chenango		Bituminous macadam		June 12	[1] 233,800.00	[1] 116,900.00
	4	Chautauqua		Concrete		June 26	[1] 61,400.00	[1] 30,000.00
	5	Columbia	7.34	Macadam or concrete		do	293,600.00	146,800.00
	9	Fulton		Macadam with surface application of tar.		June 19	[1] 15,508.00	[1] 7,754.00
	23	Schoharie	2.76	Concrete	June 2		94,100.00	47,050.00
	30	Cattaraugus	7.08	do	June 27	June 30	438,100.00	212,300.00
North Carolina	23	Burke		Topsoil		June 23		[1] 7,500.00
	37	Gaston	10.38	Bituminous macadam		June 7	167,173.23	83,586.61
	45	Buncombe	7.71	Macadam	June 30		229,447.44	114,723.72
North Dakota	3	Williams		Earth		June 23	[1] 13,150.26	[1] 6,575.13
	10	Pierce		Gravel		June 20	[1] 3,475.83	[1] 1,737.92
	24	Stutsman	25.90	Graded earth		June 26	92,336.51	46,168.25
	31	La Moure	4.79	Graded and drained		June 24	33,522.50	16,761.25
Ohio	4	Lake		Semimonolithic brick		June 4	[1] 19,590.72	
	13	Williams	2.05	Concrete, bituminous concrete, or bituminous macadam.		June 19	72,000.00	21,674.52
	20	Richland	3.38	Brick or concrete		June 27	119,000.00	40,000.00
	26	Van Wert	10.75	Concrete or bituminous macadam		June 19	292,815.00	107,500.00
	27	Hamilton	6.60	Asphalt, concrete, or brick	June 30		435,000.00	132,000.00
	33P	Clinton	3.88	Macadam		June 7	54,250.00	17,262.00
	33Q	do	5.58	do		do	77,450 00	22,736.00
	38	Auglaize	6.53	Brick, concrete, or bituminous		June 19	261,500 00	119,500.00
	46	Ashland	3.80	Concrete or brick		do	131,960.00	32,000.00
	50	Columbiana and Mahoning	4.12	Brick	June 23		152,027.30	51,000.00
	56	Montgomery	6.05	Concrete	June 3		210,000.00	70,000.00
	59	Fayette	12.80	Macadam or bituminous	June 19		305,400.00	128,000.00
	61	Wayne	4.08	Brick, concrete, or bituminous	June 23		136,000.00	50,000.00
	62	Morrow	2.56	Bituminous or concrete	June 26		101,876.94	40,000.00
	66	Defiance	2.04	Concrete	June 20		55,500.00	27,750.00
	67	Logan	11.23	Concrete	June 3		428,000.00	175,000.00
	68	Perry	4.84	Bituminous or concrete	June 20		185,000.00	66,100.00
	75	Belmont	4.00	Macadam	June 18		99,890.42	40,000.00
	76	do	4.45	do	June 7		105.000.00	40,000.00
	77	Williams	2.98	Concrete	do		109,722.80	35.000.00
	78	Mahoning and Columbiana	2.15	Brick	June 3		93,657.57	15,000.00
	79	Fulton	6.20	Macadam or concrete	June 20		205,779.64	62,000.00
	81	Pickaway	5.07	Macadam or bituminous	June 26		163,300.00	50,700.00
	87	Champaign	5.07	Concrete	June 30		178,000.00	50,700.00
	88	do	8.41	do	do		301,000.00	84,100.00
Pennsylvania	1	Clarion		Vitrified brick on concrete foundation		June 7	[1] 43,074.85	[1] 26,750.00
	2	Washington		Reinforced concrete		June 9	[1] 240,698.87	[1] 64,800.00
	3	Cambria		Brick on concrete base		June 10	[1] 122,548.74	[1] 62,340.00
	4	McKean		Vitrified brick		June 9		[1] 22,900.00
	5	Somerset		Reinforced concrete or bituminous, concrete or vitrified.		June 7		[1] 54,108.53
	6	Blair		Bituminous concrete		June 9	[1] 37,829.56	[1] 30,100.00
	8B	Erie		Cement concrete or bituminous concrete on concrete base.		June 12	[1] 31,485.06	[1] 17,188.33
	9	Butler		Reinforced concrete		do	[1] 19,929.91	[1] 29,042.41
	10	Lawrence		do		June 7		[1] 22,900.00
	11	Lycoming		do		do		[1] 55,079.19
	12	Northampton		do		June 19	[1] 99,392.12	[1] 51,500.00
	15A	Beaver		Concrete, bituminous concrete, or reinforced concrete.		June 7		[1] 10,060.00
	16	Butler		Reinforced concrete		June 9		[1] 33,300.00
	17A	Dauphin, Lebanon, Berks	24.32	Concrete		June 7	[1] 51,266.85	[1] 54,427.87
	17 B&C	do	13.15	do		do	320,170.28	160,085.13
	23	Greene	6.49	Brick or concrete		June 9	358,039.05	129,800.00
	31	Center	6.10	Bituminous and brick		June 12	274,155.45	122,000.00
	32	Chester	4.10	Concrete		June 19	165,344.87	82,000.00
	33A	Luzerne	4.25	Bituminous and concrete		do	176,867.35	85,000.00
	33B	do	2.00	do		do	112,668.24	40,000.00
	36	Blair	2.58	Concrete	June 16		119,006.80	51,600.00
	37	Butler	6.10	Concrete or bituminous	June 5		294,248.90	122,000.00
	38	Crawford	3.13	do	do		147,116.20	62,600.00
	39	Dauphin	6.40	Concrete or brick	do		314,466.90	128,000.0
	40	McKean	10.11	Concrete	do		454,985.10	206,698.45
	41	Mercer	3.39	Concrete or bituminous	do		146,139.40	67,800.00
	42	Union	2.55	do	do		95,752.80	47,876.40
	43	Wayne	5.24	do	do		256,594.80	104,800.00
	44	Cambria	6.10	Concrete	June 30		249,792.18	122,000.00
Rhode Island	1	Washington		Bituminous concrete		June 26	[1] 2,952.98	
	2	do		Bituminous macadam		June 12		[2] −12,201.05
	3	do		do		June 25	[2] −5,033.55	[2] −2,516.78
	4	do	5.00	Bituminous		June 4	128,390.02	64,195.01
South Carolina	6	Marion	3.53	Mostly bridges		June 17	86,644.50	43,322.25

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Modified agreements. Amounts given are reductions from those in original agreements.

FEDERAL BID PROJECT APPROVALS AND AGREEMENTS IN JUNE, 1919—Continued.

State.	Project number.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
South Dakota	4	Brookings	6.46	Gravel		June 23	29,908.60	14,954.30
	13	Dawson	14.00	do	June 23		58,113.00	29,056.50
	14	Stanley	18.50	Earth and gravel	do		84,862.25	42,431.12
	15	Lawrence	22.94	do	June 26		146,650.90	73,325.45
Texas	9	Lee	6.35	Gravel, concrete culverts		June 16	29,024.15	13,860.00
	21	Gregg		Bitumilus macadam		June 23	[1] 27,750.84	[1] 14,123.42
	69	[illegible]	10.00	Bituminous gravel		do	40,028.64	13,841.88
	83	Brown	10.98		June 24		91,293.55	22,500.00
Utah	5	Grand	35.10	Graded earth		June 25	135,204.18	67,602.09
	6	Grand and San Juan	23.80	do		do	144,385.45	72,192.72
Vermont	7	Windham	1.65	Gravel		June 18	24,190.43	12,095.21
	9	Orleans	2.88	do		June 4	52,090.17	26,045.08
	10	Rutland	4.30	do		June 30	68,702.31	34,351.15
Virginia	37	Bedford and Campbell	6.60	Bituminous	June 20		127,600.00	63,800.00
	38	Accomac	2.59	do	do		36,080.00	18,040.00
	45	Henry	4.50	Sand-clay	June 30		42,487.50	21,243.75
	48	Amherst and Bedford	19.10	Macadam	do		303,105.00	151,552.50
	49	Caroline and Spotsylvania	.30	Gravel	June 18		8,805.50	4,402.75
	50	Campbell	2.10	Macadam	June 20		43,120.00	21,560.00
Washington	11	Lewis	.35	Concrete bridge and gravel approaches.		June 19	141,814.23	70,907.10
	27	do	6.70	Concrete	June 19		190,388.00	95,194.00
	28	Snohomish	1.10	do	do		37,374.33	18,687.16
	29	Grays Harbor and Jefferson	17.95	Gravel	June 20		265,628.00	132,814.00
	30	Skagit	7.70	Concrete	June 3		241,392.91	120,696.45
	31	Lewis		Bridge	do		37,999.50	18,999.75
	32	Cowlitz	6.67	Gravel	June 18		271,250.10	133,400.00
	34	Clarke	6.70	Concrete	June 20		204,809.00	100,000.00
West Virginia	14	Mingo		Earth		June 16		[1] 18,925.00
	18	Tyler		Concrete		June 19	[2] −1,687.93	
	34	Monroe	2.00	Macadam		June 12	19,200.00	9,600.00
	39	Doddridge	3.00	Concrete	June 3		70,963.20	29,780.00
	40	Wood	2.00	do	June 12		36,000.00	18,000.00
	41	do	3.00	do	June 16		56,000.00	25,300.00
	45	Putnam	4.00	Brick, concrete, or bituminous	June 18		140,360.00	48,000.00
	46	Ohio	1.00	Concrete	June 19		38,000.00	18,000.00
	47	Wetzel	4.74	do	June 20		83,299.15	41,649.57
Wisconsin	7	Wakesha		Waterbound macadam		June 12	[2] −659.38	[1] 219.79
	19	Price		Graded earth		do	[1] 3,911.71	[1] 1,303.91
	80	Green	5.41	Earth	June 2		41,160.00	13,720.00
	86	Lafayette	3.46	do	June 16		33,593.70	11,197.90
	92	Brown	5.16	Concrete	June 2		116,980.00	38,993.57
	95	Milwaukee		Bridge	June 7		55,000.00	18,333.33
Wyoming	[3] 3	Lincoln			June 5			
	25	Crook	19.25	Earth	June 7		156,156.44	78,078.22
	28	Sheridan	4.16	Macadam	June 20		52,514.00	26,257.00
	34	Lincoln	17.64	do	June 7		100,597.20	50,298.60
	35	Platte	12.74	Gravel	June 19		90,799.28	45,399.64
Total	239		1,939.23				34,519,971.11	16,102,244.59

[1] Modified agreements. Amounts given are increased over those in the original agreements.

[2] Modified agreement. Amounts given are reductions from those in original agreement.

[3] Statement previously approved withdrawn.

PLANS FOR BIG ROAD WORK.

Pottawattomie County, Iowa, will vote in September on a bond issue of $3,000,000 for roads. If the election is in favor of the bonds, it is estimated that the county will spend on its roads $5,000,000 according to plans now under preparation by the board of supervisors. The additional $2,000,000 is expected to come from State and National aid. Clay County, Iowa, will vote July 22 on a road bond issue of $800,000.

CALIFORNIA COUNTY BONDS.

So far this year California counties have voted $30,000,000 in highway bonds. Their proceeds are for the building of laterals to the State highway system roads or for the improvement of county systems. At recent elections Fresno County voted $4,800,000, San Diego $2,500,000, Sonoma $1,640,000, Imperial $1,500,000, Marin and Yolo $1,000,000 each, Santa Cruz $924,000, Napa $500,000 and Modoc $400,000. The first issue of the Fresno bonds, $1,000,000, and the Santa Cruz issue have already been sold at satisfactory premiums.

GEORGIA COUNTIES VOTE BONDS.

Several Georgia counties have recently cast decisive votes in favor of proposed issues of road bonds. Chatham County, in which Savannah is located, voted June 24 in favor of an issue of $2,500,000. It is planned to make use of the funds provided at an early date in starting road construction.

Ware County, in the southern part of the State, voted by nearly 19 to 1 in favor of bonds to the amount of $630,000, while the proposed issue of $400,000 in Mitchell County, also in south Georgia, was carried by about 4 to 1. Dougherty County has sold $400,000 of bonds to local banks at par, the bidders to pay for engraving the bonds and to pay interest on daily balances at 4½ per cent, the same rate the bonds bear. Grady County has voted to issue $250,000 in bonds.

FOR HIGHWAY BONDS.

Pittsylvania County, Va., will vote in September on an issue of road bonds to the amount of $300,000.

PRIMARY ROAD MAINTENANCE COSTS

Two Years' Record of the State of Washington

By E. G. COTTERILL, Chief Engineer, State Highway Commission.

ON June 7, 1917, the State of Washington inaugurated the plan of State-controlled, county-administered maintenance of its primary highway system. State funds, derived from the motor-vehicle license revenue, are apportioned to the counties "for the sole purpose of maintaining and repairing primary and permanent highways or highways of like character and for equipment for the maintenance thereof." The primary highways are required to be maintained by the counties "under such rules, regulations, and requirements as may be prescribed by the State highway board." In case any county administration is delinquent or deficient in maintaining any section of primary highway up to the prescribed standards, the law authorizes direct maintenance by the State highway department at the expense of the county apportionment of funds until the delinquency is overcome.

THE MAINTENANCE SYSTEM

At the outset, 1,245 miles of constructed primary highways came under the operation of this system of State control of county administered maintenance. By June of 1918, the mileage had increased by completion of new construction to 1,410 miles, and at this writing (July, 1919) by completed construction and additional routes designated by the recent legislature as primary highways, a total of 1,796 miles is under the joint maintenance plan. This will continue to increase at the rate of 200 to 300 miles annually for the next three or four years until the entire 2,700 miles of designated primary highway system is completed with permanent construction.

Although this primary mileage comprises only about 5 per cent of the established road system throughout the State (excluding streets withinc orporate limits of cities and towns), it is certain that at least 50 and perhaps as much as 75 per cent of the entire volume of highway traffic is carried by these primary routes, upon which the through and local travel is concentrated.

The principle of making the upkeep of these primary highways a prior claim upon the motor-vehicle license revenue—whether administered by State or counties—is economically sound and has proved its adequacy in practice. Prior to 1919 the license schedule, graded generally on the basis of weight and horsepower, averaged about $7 per vehicle, and all the revenue (over cost of license administration, about 10 per cent of collections) was apportioned to the counties for maintenance. The 1919 legislature, desiring to increase the construction fund, practically doubled the license schedule to an average of about $16 per vehicle. This assures about $2,000,000 revenue in 1919 and probably $2,250,000 for 1920. The first $1,000,000 annually (after license administration expense), is required to be apportioned to the counties and municipalities for the maintenance and upkeep of the primary highways within their limits as a prior obligation. After meeting this adequately, any surplus in the county apportionments is available for maintenance of the county permanent highways other than on primary routes.

STATE CONTROLS MAINTENANCE

In the exercise of State control over county administration of primary highway maintenance, the State highway board in June, 1917, prescribed in detail the methods and standards to be applied and required, including a uniform system of cost-keeping and monthly reports, thus compiling a continuing cost record of the maintenance and repair expenditures upon each section of highway. This cost-keeping system includes the following main features:

(*a*) The primary highways in each county are divided into consecutive sections in accordance with their respective types of construction and surfacing.

(*b*) The county or maintenance engineer in charge prepared each December an "annual cost estimate" for each section of highway on a prescribed form providing for a distributed estimate against the following segregated cost items, viz, patrol, drainage, dragging and dressing, clearing, removing obstructions, resurfacing and repair, sprinkling, sanding, structures, safeguards and signs, industrial insurance, equipment and supplies, supervision and contingencies—the latter being 10 per cent of the sum of all items preceding. These annual cost estimates are reviewed, and modified as deemed necessary, by the county board of commissioners and finally are subject to approval of State highway commissioner. The approved estimate for each section becomes its advisory budget for ensuing calendar year and the total of all approved estimates in each county is set aside from the apportioned maintenance fund to meet the expenditures as they may be required.

(*c*) The engineer in charge prepares monthly reports of actual expenditures upon each section on a form segregated into cost items corresponding with the annual estimate, and extending in appropriate columns a simple system of budget bookkeeping for each item. The respective columns on each monthly report indicate "expenditure, month reported"; "previous months, calendar year"; "total to date, calendar year"; "budget balance (or *deficit)." Each monthly report is prepared in duplicate, one for the county record, the other certified to the State highway commissioner. There is thus provided and expenditure report cumulative each month, by which the responsible county and State authorities at all times have a permanent record of the physical and financial status of every section of primary State highway subject to their maintenance administration and control.

(*d*) Special forms provide for detail explanation of annual estimates and monthly charges for "equipment and supplies" and for "supervision," making a record of the apportionment of these general items as between the respective sections of highway upon which they are applied.

COST-KEEPING RECORDS.

Two years of cumulative cost-keeping records of Washington primary highway maintenance are now available. They cover about 250 separate sections of highway averaging each nearly 6 miles length; including 11 types of construction and surfacing. Their maintenance is under the direct administration of 30 boards of county commissioners and their county or maintenance engineers in charge. With an average of about 50 miles of primary State highway in each county, the maintenance organization covers these along with the larger group of main county and tributary highways, making the necessary apportionments for "overhead" supervision equipment, etc., as between the respective groups.

NOTE.—It may be opportune to emphasize the point just stated as the economic basis which supports the argument for county administration of maintenance of primary State highways under State regulation, as compared with direct State administration. Inasmuch as every county has, and must continue in any event, its organization and equipment for the maintenance of several hundred miles of county highways over which it has sole jurisdiction, is not this existing county organization best equipped to most economically and efficiently cover the 50 to 100 miles of State highway within the same county territory? Is it wise or necessary to duplicate maintenance equipment and organizations by superimposing a separate State maintenance administration upon the relatively small proportion of primary highway mileage within each county? Will not a centralized State highway department control and direction of county maintenance administrations applied to primary State highways, with State authority to prescribe and enforce standards of maintenance and with requirement of uniform cost-keeping and records of the expenditure of the State funds apportioned for the upkeep of these main roads, best serve the common public purpose? Moreover, will not the tendency be to expand the application of the State-prescribed standards and requirements for adequate maintenance of the primary highways, to the other main and tributary county highways and thus uplift and establish the entire highway maintenance plan and organization in all the counties? Thus runs the argument for the joint system of State control and county administration as in force in Washington. There is another side to this argument and there are some decided offsets in favor of the concentration of all trunk highway maintenance under direct State administration irrespective of county organizations and boundaries. The figures of comparative maintenance costs of similar roads in adjacent counties are suggestive of decided differences of efficiency between county organizations, which concentrated State administration should overcome.

The tabulated statements which follow are a summary of the expenditures charged against the primary highways of Washington for their maintenance, repair, and equipment therefor during the past two years (June, 1917, to May, 1919, inclusive), as reported by the county engineers in charge to the State highway commissioner. They are classified—

(A) By counties exercising direct administration.

(B) By highways, as designated in the State primary system.

(C) By types of construction and surfacing.

ALL CHARGES ON ROAD INCLUDED.

For correct understanding of the tabular statements and making fair comparisons therefrom, it must be borne in mind —

(*a*) That the expenditures listed and averaged per mile include all charges upon the entire road, its drainage, roadbed, slopes, shoulders, etc., as well as the pavement or surfacing —everything that has been necessary for the adequate maintenance, repair, and general upkeep of the highway.

(*b*) That equipment purchases make up about 15 per cent of the total expenditures, varying from nominal up to 50 per cent in the various counties, apportioned upon the respective highway sections to which applied. While this operates fairly as a general State average, there are disproportionate equipment charges as between the several counties, which will not work out in fair comparison until at least four or five years of continuous records on this plan are made available.

(*c*) That the traffic on the various sections of highways included in these statistics varies from 100 to 200 vehicles per day (in such counties as Adams and Franklin) up to 2,000 to 4,000 vehicles per day (in such counties as King, Pierce, and Spokane on the highways tributary to Seattle, Tacoma, and Spokane). Any comparisons between the relative county averages of cost of maintenance per mile must take this volume of traffic into consideration, especially in the case of macadam and gravel-surfaced highways.

(A) STATE OF WASHINGTON—PRIMARY HIGHWAYS.

Expenditures for maintenance, repairs, and equipment, June, 1917–May, 1919.

Name of county.	Year June, 1917–May, 1918.		Year June, 1918–May, 1919.		Annual average cost per mile-year.
	Mileage	Cost per mile.	Mileage.	Cost per mile.	
Adams	25.28	$36.08	25.28	$112.58	$74.33
Asotin	2.27	283.10	2.27	50.00	166.55
Benton	38.84	359.38	44.67	390.40	374.86
Chelan	10.39	113.59	22.24	435.35	274.47
Clallam	76.45	267.31	76.74	522.80	395.05
Clarke	18.04	429.60	28.82	404.28	416.94
Columbia	19.63	557.11	23.46	447.35	502.23
Cowlitz	21.07	730.48	26.67	552.70	641.59
Douglas	23.17	108.68	31.69	432.51	270.60
Franklin	1.94	8.34	19.16	180.58	94.46
Garfield	5.78	982.50	5.78	288.80	635.65
Grant	20.68	143.89	38.3	246.67	195.28
Grays Harbor	69.73	596.88	76.17	864.53	730.70
Jefferson	31.84	237.67	34.81	334.25	285.96
King	119.68	928.17	119.68	951.65	941.41
Kittitas	75.88	219.68	98.28	159.71	189.70
Lewis	77.90	157.31	77.90	463.88	310.60
Lincoln	39.15	354.65	69.03	254.82	304.73
Mason	46.50	165.13	52.07	206.99	186.06
Pacific	37.56	139.70	55.65	375.61	257.65
Pierce	81.47	160.81	86.21	402.92	281.86
Skagit	27.00	536.20	27.25	417.14	476.67
Snohomish	42.41	234.48	44.12	157.36	195.92
Spokane	94.57	171.93	106.29	544.57	358.25
Stevens	8.91	164.62	8.91	339.08	251.85
Thurston	50.17	165.51	56.49	257.98	211.75
Walla Walla	40.55	320.58	45.69	297.81	309.20
Whatcom	13.48	163.03	21.06	227.85	195.44
Whitman	64.27	442.37	65.30	270.57	356.47
Yakima	118.85	173.77	122.76	291.63	232.70
30 counties	1,303.87	327.84	1,512.79	419.86	373.85

(*d*) In general, and to a marked extent in certain counties, the cost statistics are made higher than ordinary maintenance should be, by the inclusion of incidental improvements to the highways, such as occasional widenings, additional drainage facilities, bank protection along streams, providing guardrails and other safeguards of traffic, removing slides, etc. Most of the Washington primary highways are new onestruction of the past six years, and under a liberal application of the term "maintenance and repair" any defects or minor errors which are revealed by use and with the effects of the elements at recurring winter and flood seasons, are supplied and overcome from the maintenance funds. Thus, with the exception of pavements and structures, it can be demonstrated that the Washington primary highways have been decidedly improved by continuing maintenance more than they have been worn out by the traffic. Maintenance expenditures should tend to decrease in comparison with the record of the past two years because of these incidental improvements and repairs of new construction which have been liberally classified and charged to maintenance.

(B) STATE OF WASHINGTON—PRIMARY HIGHWAYS.

Expenditures for maintenance, repairs, and equipment, 1917–18.

Name of highway.	1917 (7 months June–Dec.).			1918 (full year).			1917–18, cost per mile-year.
	Mileage.	Expenditure.	Per mile	Mileage.	Expenditure.	Per mile.	
Pacific Highway	237.54	$45,875.29	$193.13	258.09	$107,171.13	$415.25	$384.24
Sunset Highway	227.99	43,578.31	191.14	281.16	93,218.02	331.54	330.11
Inland Empire Highway	310.14	51,746.94	166.88	336.93	136,132.45	404.04	360.58
National Park Highway	124.39	5,884.58	47.31	155.59	54,592.82	350.87	251.48
Olympic Highway	232.36	41,878.38	180.23	250.55	111,288.96	444.18	394.36
McClellan Pass Highway	71.27	20,295.53	284.77	79.27	50,731.67	639.98	584.05
Central Washington Highway	41.88	1,570.86	37.51	48.94	6,633.43	135.54	109.30
Primary highway, Total	245.57	210,829.89	169.26	1,410.53	559,768.48	396.85	357.54

(C) EXPENDITURES 1917–18, CLASSIFIED BY HIGHWAY CONSTRUCTION TYPES.

Type of surfacing.	1917 (7 months June–December).			1918 (full year).			1917–18, cost per mile-year.
	Mileage.	Expenditure.	Per mile	Mileage.	Expenditure.	Per mile.	
Brick Pavement [1]	8.81	$9,456.51	$1,073.38	8.81	$6,652.29	[1] $755.08	$914.23
Cement concrete	90.59	5,110.60	56.41	102.38	11,427.54	111.61	106.12
Asphaltic concrete	19.74	322.21	16.32	23.24	7,871.09	338.68	224.21
Bitulithic and warrenite	14.41	3,040.50	211.00	17.77	5,143.54	289.45	316.07
Sheet asphalt	5.97	326.05	54.61	5.97	207.07	34.68	56.39
One-half width concrete, one-half width macadam, etc.	7.80	1,798.50	230.58	8.53	2,461.81	288.61	327.91
Bituminous macadam	42.21	5,895.67	139.67	40.96	20,071.85	490.03	397.70
Water-bound macadam	122.85	20,297.41	165.22	125.05	52,335.59	418.53	368.67
Crushed rock surfacing	54.03	8,396.81	155.41	66.30	32,063.53	483.61	403.59
Gravel surfacing	756.33	138,199.34	182.72	825.81	353,845.15	428.48	386.02
Natural earth grade	121.28	10,511.82	86.67	182.13	30,185.56	165.73	159.42
Special, bridges, trestles, etc	[2] 1.55	7,474.47		[2] 3.58	37,503.46		
All types, total	1,245.57	210,829.89	169.26	1,410.53	559,768.48	396.85	357.54

[1] Abnormal expenditures on brick pavement is due to extensive repairs and replacements account faulty construction and road-bed settlements. The 1917–18 average per mile year obtained by adding annual averages and equal division of sum. In all cases of other types than brick, the 1917–18 mile-year average is obtained by dividing sum of annual averages by 1.5833, on account 7 months of 1917 averaged with full year 1918.

[2] This item represents unusual expenditures on bridges, trestles, etc., such as replacements, redecking, etc., amounting practically to reconstruction, and therefore excluded from ordinary maintenance cost of the highway sections in which located.

ABNORMAL USE SWELLS COSTS.

(*e*) On certain sections of the McClellan Pass Highway in King County and of the Olympic Highway in Clallam and Grays Harbor Counties, the Federal Government spruce operations of the war period imposed a most abnormal and destructive use upon more than a hundred miles of gravel-surfaced highways. Extension trucks carried great logs, often to aggregate weights of 20 to 25 tons, over miles of roads unfitted for such abnormal use; but with no other transportation resource from the spruce forests, these roads were devoted to the national service. In order to keep up these roads under such traffic, it required on the McClellan Pass Highway in King County an expenditure during 1918 of $1,861.37 per mile for the 19-mile section east of Emmclaw, which was the scene of the spruce-hauling operations. Similarly on the Olympic Highway in Grays Harbor County south from Lake Quiniault it cost almost $1,000 per mile to keep up the 37 miles of gravel-surfaced highway during 1918. These abnormal upkeep costs swell the figures from these counties and types of highway.

(*f*) The years covered by these tabular statements, beginning with June, 1917, have witnessed the highest scale of labor and material costs ever known. Common labor had reached the $3.75 mark before June, 1917, and rose to $4.50 and $5 during 1918, at which level it remains in June, 1919 (for day of eight hours). This represents a full 100 per cent increase from the $2.25 to $2.75 rates for similar labor in the prewar period. And the materials necessary for maintenance work have risen in almost similar doubled proportion. The Washington primary highway average of almost $400 per mile maintenance cost in 1918—and five months of 1919 shows a continuance at about this rate—is fairly comparable with $200 per mile during the period of 1910–1916.

SAVING ON HARD-SURFACED ROADS.

At least one general conclusion is fairly deducible from the Washington figures of two years' maintenance costs, viz, that there is a gap of $250 to $300 per mile per year between the group of hard-surfaced paved highways and the macadam-gravel group. Considering further that the paved highways carry a volume of traffic per mile, averaging two to ten times that of the macadam-gravel group, it is demonstrable from detail analysis of sectional reports that macadam-gravel sections under traffic comparable with paved sections are costing from $600 per mile per year and upward for their upkeep. In other words the real gap between maintenance cost of paved and macadam-gravel highways under similar heavy traffic is at least $500 per mile per year. Assuming a traffic of 500 motor vehicles per day or 182,500 per year, it is certain that not less than 1 cent per mile—some would place it as high as 2 cents—will be saved to the motor operating public, or $1,825 per year per mile, in actual upkeep cost of motor vehicles employed, to say nothing of increased traction results, time saved and convenience served. Adding the $500 per mile of increased annual maintenance cost and $1,825 per mile of motor vehicle upkeep cost makes a showing of $2,325 per year per mile which can be saved by substituting a hard-surface pavement for macadam or gravel surfacing. Half this amount would pay the interest on an investment of $25,000 per mile in pavement.

Whenever the traffic on a macadam or gravel surfaced highway approaches an average of 500 motor vehicles daily, the Washington experience, demonstrates costs of $600 to $1,000 per mile for such uneffective degree of upkeep as is possible for these highway types under such traffic. In every such case a hard-surface pavement is economically over-due; and the Washington program is to get these roads up to date by hard-surface construction as fast as resources and credit will permit.

TEST AND RESEARCH INVESTIGATIONS OF THE BUREAU OF PUBLIC ROADS

By PRÉVOST HUBBARD, Chemical Engineer.

ON July 1, 1915, all of the testing and research work of the Bureau relating to road materials was consolidated under one head, thus creating the Division of Road Material Tests and Research. The work is divided under six main sections, each in charge of an investigator, who reports directly to the chief of the division. There is also a small clerical force and a machine shop, whose work is distributed as required. In addition to written reports from each section, progress of work is recorded on a large blueprint chart, copies of which are posted in the various offices and laboratories. This chart shows the monthly progress on each separate investigation which is undertaken, together with the names of employees engaged thereon. The following brief descriptions of investigations at present under way will serve to illustrate the scope and character of work performed by the division in addition to its regular routine testing and cooperation on Federal aid projects.

EFFECT OF MOTOR TRUCK TRAFFIC ON HIGHWAYS.

The recent heavy increase in motor truck traffic has brought forward problems of legislation, regarding the maximum weight and speed of motor trucks, which require immediate solution in order that adequate laws may be enacted to protect existing roads from rapid destruction and to furnish a guide for the design of future roads. Such legislation should, of course, be based only upon sound judgment and full investigation. At the present time, however, there is little definite knowledge regarding the relative destructive effects exerted by different weights of trucks operating at various speeds. It is known, of course, that a heavy truck exerts higher impact stresses than a light truck as may be readily observed by the relative vibration produced in slab pavements of any kind during the passing of heavy and light trucks. The effect of speed is known in a general way, but it is very desirable, in order to obtain definite knowledge on the relative destructive effects, that some measure be obtained of the impacts exerted by different sizes of trucks operating under different speeds. The tire question, too, is one that requires investigation in view of the claims made for the recently advocated large size pneumatic tires.

In order to obtain information upon these problems a series of tests is now being conducted at the Arlington Experimental Farm in which the impact effects of motor trucks are being measured. For this investigation, a scheme is employed similar to that used in the Ordnance Department of the Army for obtaining gun pressures. It consists in subjecting a small copper cylinder to the effect of the blow and measuring the resulting deformation of the cylinder.

The next step in a complete investigation of the destructive effects of truck loads is to actually subject test sections of roads to corresponding impact effects. A machine has been designed and is now being built which will exert the same kind of impact that is exerted by motor trucks. The machine consists of an unsprung weight together with a sprung weight as in the case of a motor truck. The entire weight is raised by means of a cam and allowed to drop a great number of times so that the impact will be exerted on the same spot. This machine will be used in testing pavement slabs laid directly on a prepared subgrade. It is the aim to include in this investigation a large number of typical road sections, including concrete of different thicknesses and proportions, both plain and reinforced; 3 and 4 inch brick pavements of various types, such as monolithic, semimonolithic, and sand-cushion construction, using repressed, wire-cut lug and vertical fiber brick, with bituminous as well as cement grout filler; and sections of bituminous concrete and other types of pavement with and without concrete base.

The scheme of testing contemplates continued impact action by means of the above described machine until noticeable failure occurs. It is proposed to make all the necessary deflection measurements that may be required during the progress of the test.

It is believed that as a result of these investigations it will be possible to state definitely that any designated type of road is capable of withstanding a definite number of vehicles per day when laid on a known kind of subgrade. It is proposed to make the tests on two kinds of subgrades, one that is well drained and one that is purposely kept in a soft condition. These are the two extreme conditions of subgrade on which the ordinary road is actually laid. The following slabs 7 and 14 feet square will be tested in the immediate future and additional sections of various pavements will be constructed for test at a later date.

1. Plain concrete:
   2, 4, 6, 8, 10 inches thick by 7 feet square, also 6 inches thick by 14 feet square.. Poor subgrade.
   Do........................... Good subgrade.

2. Monolithic construction—Wire-cut lug brick:
    1-inch screenings.................Good subgrade.
    1, 2, 4, 6 inch concrete base ....Poor subgrade.
    Do........................ Good subgrade.
    6-inch concrete base, soft brick.... Do.
3. Monolithic construction—Vertical fiber brick:
    4-inch, 6-inch concrete base.......Good subgrade.
4. Monolithic construction—Repressed brick:
    4-inch, 6-inch concrete base.......Good subgrade.
5. Semimonolithic construction—Wire-cut lug brick:
    4-inch, 6-inch concrete base.......Poor subgrade.
    Do........................Good subgrade.
6. Sand cushion construction—Wire-cut lug brick:
    4-inch, 6-inch concrete base.......Poor subgrade.
    Do........................Good subgrade.
    4-inch, 6-inch concrete base, using 1-inch screenings. Do.
7. Wire-cut lug brick—Grout filler:
    6-inch, 12-inch macadam foundation. Poor subgrade.
    Do........................Good subgrade.
8. Vertical fiber brick—Bituminous filler:
    4-inch, 6-inch concrete base, sand-cement cushion. Poor subgrade.
    6-inch concrete base, sand-cement cushion. Good subgrade.
9. Vertical fiber brick—Bituminous filler:
    4-inch, 6-inch concrete base, sand cushion. Poor subgrade.
    6-inch concrete base, sand cushion. Good subgrade.
    4-inch, 6-inch concrete base, sand cement cushion screenings. Do.
10. Wire-cut lug—Bituminous mastic cushion and filler:
    4-inch, 6-inch.................Poor subgrade.
    6-inch........................Good subgrade.

WEAR TESTS OF PAVEMENT SECTIONS.

By means of a series of wear tests now in progress, it is hoped to obtain information of considerable value regarding some of the problems involved in the selection of materials for vitrified brick, stone block, and concrete pavements. In these tests the various materials are being subjected to wear in pavement sections, laid as in actual construction. In the brick and block sections this makes it possible to observe the influence exerted by different types of joint fillers and bedding courses. In other words, the constituents of a highway are tested in combination instead of separately as is the usual laboratory practice. A detailed layout of the various sections now under construction is as follows:

GROUP A—VITRIFIED BRICK.

Section No.	Type brick.	Grade of brick rattler loss per cent.	Type filler.	Type bed.
1	Repressed	16	Cement grout	1 inch sand-cement
2	Wire-cut lug	16	do	Do.
3	Repressed	18	do	Do.
4	Wire-cut lug	19	do	Do.
5	Vertical fibre lug	19	do	Do.
6	Repressed	24	do	Do.
7	Wire-cut lug	23	do	Do.
8	Repressed	16	Asphalt	1 inch sand.
9	Wire-cut lug	16	do	Do.
10	Repressed	18	do	Do.
11	Wire-cut lug	19	do	Do.
12	Vertical fibre lug	19	do	Do.
13	Repressed	24	do	Do.
14	Wire-cut lug	23	do	Do.
15	do	19	do	1 inch asphalt sand.
16	do	19	Asphalt mastic	Do.

GROUP B—STONE BLOCK.

Section No.	Type block.	Grade of block fr. coeff. wear	Type filler.	Type bed.
1	Granite	12	Cement grout	1 inch sand-cement
2	do.	11	do	Do
3	do.	10	do	Do.
4	do	9	do	Do
5	do.	12	Asphalt	1 inch sand
6	do.	11	do	Do
7	do.	10	do	Do
8	do.	9	do	Do
9	do	12	Asphalt mastic	Do.
10	do	11	do	Do.
11	do	10	do	Do.
12	do.	9	do	Do.
13	do.	12	do	1 inch asphaltic sand.
14	do.	9	do	Do.

GROUP C—CONCRETE.

Section No.	Grade of concrete.
1	1:1½:3, limestone aggregate.
2	1:1½:3, sandstone aggregate.
3	1:1½:3, granite aggregate.
4	1:1½:3, trap aggregate.
5	1:1½:3, gravel aggregate.
6	1:1½:3, slag aggregate.
7	1:1½:3, very soft sandstone aggregate.

Each section is 10 feet long and 2 feet wide, and is laid on a concrete base 8 inches in depth which in turn rests upon a 12-inch cinder subbase. Reinforced concrete curbs 6 inches wide by 30 inches in depth act as rigid supports on both sides and also serve to carry the rails on which the wear machine travels. Figure 3 shows the curbs in place and the compacted cinder fill ready for the concrete base.

WEAR BY HEAVY STEEL TIRED VEHICLES.

A wear testing machine has been designed to approximate the wear produced by heavily loaded steel-tired vehicles. It consists essentially of 5 cast-iron wheels 48 inches in diameter and 2 inches wide, each weighing 1,000 pounds. The wheels are mounted inside of a channel iron frame in such a way that they roll over the center 12 inches of the 24-inch test strip. Each wheel is mounted independently of the others so as to be free to move up and down and thus adjust itself to inequalities and depressions in the pavement along the line over which it travels. The wheels travel the length of a 400-foot section three times in two minutes, or at approximately 6 miles per hour. The amount of wear produced is measured by means of an Ames dial mounted on a straight edge which in turn rests upon plugs set in the sides of the section at various points along the test strip. This device is also used to measure the wear of various types of pavement under actual traffic.

If it is found that the abrasive action of the wheels is too slow, means will be provided for accelerating wear either by installing an arrangement to imitate the impact produced by horses' hoofs or by allowing the wheels to roll off of a series of ramps arranged so that each wheel will drop a short distance before striking the pavement. After the abrasive tests have been run on all of the important types of pavement, it is planned to modify the machine so as to determine the shoving effect of fast-moving, rubber-tired wheels on various types of bituminous pavements.

DISTRIBUTION OF PRESSURES THROUGH EARTH FILLS.

An elaborate series of tests has been under way for several years for determining the distribution of concentrated pressures through earth fills. This is a problem in connection with bridge design and its solution will also be useful in questions of road design as well as for the design of footings and foundations. The measurement of the pressure exerted by earth or of the pressure transmitted through earth is an exceedingly difficult operation. The difficulty lies in the fact that the earth is not liquid but possesses a slight amount of elasticity and there is more or less internal friction and cohesion between the particles. Any instrument for measuring earth pressures must perform its function without appreciable movement of the instrument itself, for any movement of the instrument against or away from the earth either increases or decreases the pressure exerted by the earth.

In order to take care of these difficulties, a special diaphragm cell has been designed. These cells are buried in the fill wherever it is desired to ascertain the pressure and a small pipe is laid from the cell to a convenient position for taking measurements. The cell is designed so that when air is introduced into it through the pipe electrical contact is broken within the cell at the exact instant that the air pressure within equilibrates the earth pressure on the cell. The air pressure is read at that instant by means of a pressure gauge. Thus far, a large number of tests have been made for determining the distribution of pressures through sand fills in depths up to 5 feet.

The pressure exerted by earth back of retaining walls has long been the subject of speculation rather than certainty. A number of theories have been advanced for the purpose of calculating these pressures, but all of these theories are arrived at from a mathematical standpoint and are not based on sound experimental data. For the purpose of obtaining enough information to check up some of these theories, a series of tests has been started to determine the actual pressures being exerted against retaining walls. The procedure is to bury a number of pressure cells against new walls before the fill is made. After the earth fill has been placed, a series of readings of the cells are made extending over a period of more than one year. These results will finally be worked up in a form such that a rational theory for retaining wall pressures may be obtained. Thus far, the pressures back of two high walls have been measured.

SOIL STUDIES.

In connection with the distribution of pressures through earth, the physical laboratory is working on methods for determining the physical properties of soils. This includes a method for determining the relative bearing power of soils of different mechanical composition and different water-holding capacity and also rapid as well as accurate methods for the mechanical analysis of soil samples from the standpoint of their classification, use as road foundations or subgrades and as surfacing materials. The subgrade ultimately carries the load to which the road is subjected and when it is considered how greatly soils vary in their bearing capacity, the importance of this work becomes apparent. The laboratory is working in a new field along this line because studies of the physical properties of soils have been made so far almost exclusively for the purpose of agricultural analysis. A means for artificially compacting soil samples in the laboratory so as to approximate their conditions in nature has been worked out, as has also a more rapid and simpler method of analysis than has heretofore been used.

DISTRIBUTION OF PRESSURES THROUGH HYDRAULIC FILLS.

In the construction of large earth dams for impounding water as a means of flood control or for other storage purposes, recourse is had at the present time to the hydraulic fill method of construction. In this method the general procedure is to wash material from the bank, near the site of the dam, by means of powerful jets of water. This material may consist of large pieces of rock graded down through gravel and sand to silt and exceedingly fine clay. The water mixture of materials is carried by means of a flume toward the center of the dam. The very coarse particles deposit first and as the stream approaches the center of the dam the smaller particles settle until finally there is left a pool of muddy water extending across the valley in the center of the dam. As the sides build themselves up in this way the mud in the pool of water settles out and ultimately a clay core wall is formed in the center of the dam with sides composed of increasingly coarser material as they extend outward. In several instances these dams have progressed almost to completion when suddenly an entire side of the dam has been moved outward causing the loss of thousands of cubic yards of material and requiring an enormous amount of labor to continue the construction. The cause of these failures is the immense pressure exerted by the core wall which is still in liquid condition. The exact pressure exerted by these core walls is unknown and it has been extremely difficult for engineers to design hydraulic fill dams on this account.

At the request of the Miami conservancy district the bureau undertook a series of investigations for determining just what pressure is developed in hydraulic fills such as occur in the center of hydraulic fill dams. For this purpose a standpipe was erected and the process of filling this pipe with very fine clay was conducted in a manner similar to the filling of the core wall of an hydraulic fill dam. Pressure cells were immersed in this clay fill during construction and readings have been taken extending over a period of practically two years so that much information has been obtained on the actual pressures exerted by hydraulic fills in depths up to 40 feet.

TESTS OF REINFORCED CONCRETE SLABS CARRYING EARTH FILLS.

In the past, reinforced concrete slab bridges have been designed under a variety of assumptions regarding the width of slab which should be considered as carrying a concentrated load. These assumptions were so variable that the thickness of slab obtained through their use was quite different for carrying exactly the same load. In order to obtain specific information on the design of slabs the laboratory started a series of reinforced concrete slab tests some six years ago. Enough information has been obtained to form a basis for the rational design of slabs directly supporting a concentrated load. An earth fill on top of a slab serves, however, to distribute concentrated loads so that the effect of the fill should be to increase the width of slab which may be counted upon to support the load.

In order to obtain exact data on the effect of the earth fill, a new series of tests will be started for obtaining the "effective width" of the reinforced concrete slab having different thicknesses of earth fill and subject to concentrated loads. The slabs will be 16 feet in span length and of various thicknesses and depths. The loading blocks will be shaped like the wheels of trucks and the test data will include strain-gauge measurements of the distribution of stress in the steel-reinforcing as well as earth-pressure measurements, in order to obtain the distribution of the concentrated loads through the earth fill to the slab.

DISTRIBUTION OF PRESSURES THROUGH ROADS.

A short investigation has recently been completed showing how a concrete road slab distributes a heavy superimposed load to the underlying subgrade. Numerous instances are at hand in which slabs, both of brick and of concrete, have failed particularly on soft subgrades when subjected to heavy traffic, and it was with the idea of obtaining some specific information on the slab action of such structures that this investigation was started. The soil pressure cells previously described were placed on the subgrade of a concrete road just before the concrete was deposited. After traffic was allowed on the road a heavy army truck loaded with 5 tons of sand and weighing 17,000 pounds on the rear axle was placed in particular positions with respect to these cells. In this way, the distribution of the concentrated loads to the underlying subgrade was measured. It was found that the greatest intensity of pressure occurred directly under the load and was equal to about 6½ pounds per square inch. The pressure vanished to 0 at a distance of 6 feet from the load so that, in general, it may be said that the load was carried by means of a cone pressure of 4 feet in radius.

On the basis of these tests, the stress in a concrete road 8 inches in thickness laid on a rather soft subgrade has been determined to be only about 34 pounds per square inch. In view of the low stress, investigations along this line have been discontinued as it is believed that the necessary strength of road slabs may be more correctly ascertained by subjecting them to impact rather than to static loads.

PRESSURES OF CONCRETE AGAINST FORMS.

The design of wooden forms for concrete construction involves a knowledge of the pressure exerted by the concrete in these forms. Such knowledge at the present time is rather uncertain and in view of the availability of instruments in this office for making such investigations and the obvious need for results of this character in the design of forms for bridge and wall construction, a short investigation has been practically completed showing the pressures exerted by concrete of different mixtures and consistencies. These results will be of value in aiding the concrete designer in properly proportioning the ties and braces in all form construction.

SLAG INVESTIGATIONS.

Throughout the country in the vicinity of the steel mills there are millions of tons of blast-furnace slag incidentally produced in the manufacture of steel. The slag has been deposited in huge banks and until recently much of it has been considered as having little commercial value. Lately, however, a great deal of slag has been used in the construction of roads and in the making of concrete and reinforced concrete structures. It has been claimed that in some cases the slag has given poor results and many engineers fear that on account of various chemical constituents of the slag rusting of reinforcing steel may result from its use as the coarse aggregate in concrete. It is also felt by some engineers that there is considerable danger that the concrete made from some slags will be unsound.

In view of the growing importance of the slag industry and the economic possibilities in its use for road and bridge construction, an investigation has been undertaken in order to determine just what physical and chemical characteristics slags should have in order to make them absolutely safe for structural purposes. These investigations have been begun by having representatives from the bureau take samples from most of the slag banks that are being worked in this country at the present time, obtaining information on the process of slag production and observing slag concrete construction. The laboratory investigations will involve crushing strength tests of concrete using slags of various weights from various localities, as well as a special abrasion test in the Talbot-Jones rattler made to determine the minimum weight of slag per cubic foot which should be allowed as coarse aggregate in concrete road construction. The effect of slag concrete on the preservation or corrosion of reinforcing steel is likewise to be undertaken and the ultimate aim will be to obtain all of the information necessary for drawing safe specifications for slag wherever it is desirable to make use of it.

In addition to the investigation of blast furnace slags, a study is also being made of various smelter slags, of which there exist enormous quantities. These slags are being subjected to chemical and microscopic examination for the purpose of classification and when they appear to be suitable for highway work they are subjected to the ordinary tests for road-building rock. They are also used to make up concrete test specimens.

STANDARDIZATION OF COMMERCIAL SIZES OF BROKEN STONE.

In connection with the production of broken stone for highway purposes, a considerable amount of work has been done in connection with the standardization of commercial sizes. A survey of stone quarries throughout the country has been undertaken for the purpose of studying the details of plant operation as related to the character of output. Quarries in most of the section east of the Mississippi River have been covered and results of these investigations have been published. The work is being continued and it is hoped that the general adoption of certain standard sizes will soon be brought about and will remedy the present chaotic condition of the industry, both in the interest of the highway engineer and the manufacturer. The importance of this investigation may be illustrated by the citation of one instance in which it was found that owing to variations in the demands of engineers within a very restricted area, revolving screens with as many as 22 different size openings were being used to produce for all practical purposes 6 commercial sizes of broken stone.

INVESTIGATION OF COST OF PRODUCING BROKEN STONE.

A detailed study of the cost of producing broken stone is being made at a number of typical quarrying, crushing, and screening plants. Already sufficient data has been secured and worked up into such form as to be of very practical value, both to the commercial quarry operator and to the engineer or contractor who wishes to open up and work local deposits for individual jobs. This investigation involves comparisons of cost of various methods of drilling, blasting, breaking boulders, delivery, crushing, screening, pumping, and waste disposal, both at large and small scale plants.

INVESTIGATION OF ABRASION TESTS.

The physical laboratory is constantly engaged in the routine testing of all types of nonbituminous road materials but also undertakes various investigations in connection with laboratory methods. At present an extended investigation is under way relative to a modification of the standard abrasion test for rock. This also involves the development of a special abrasion test for stone block and the development of an abrasion test for gravel.

Although the Deval test has in general been considered fairly reliable, certain defects have recently been pointed out which indicate that it can be considerably improved. Among these may be mentioned the accumulation of dust inside the cylinder during test which, acting as a cushion, considerably decreases the amount of wear, especially in the case of the softer limestones and sandstones. Variation in the amount of wear are also caused by variation in the shape of the pieces composing the charge, and the length of time required for making the test. The laboratory is working on this problem in conjunction with the road materials committee of the American Society for Testing Materials and hopes soon to present a revised test.

A satisfactory method of determining the resistance to wear of gravel has not as yet been devised owing principally to the difficulty of obtaining samples for test composed of pieces of definite size. The fact that gravel fragments have round instead of sharp edges greatly reduces the amount of wear, as compared with broken stone, unless an abrasive charge is used. Tests are now being made to find out what sizes of gravel and what kind of abrasive charge should be used in order to obtain comparable results.

A modified abrasion test applicable to stone block is also being developed in the laboratory to meet criticisms of the Deval test which has been used heretofore for determining the resistance to wear of such material. The test will make use of small machine-broken cubes of stone, all of substantially the same size. The exact number of cubes to use in a test charge has not as yet been determined, but will probably be much smaller than the number used in the Deval test. It is planned to correlate the results of this test with the wear tests of stone block pavement sections which have been described.

INVESTIGATION OF BITUMINOUS MATERIALS.

In the chemical laboratory investigations are conducted relative to methods of testing bituminous materials in addition to regular routine work. The laboratory also cooperates in the planning and supervision of experimental bituminous construction and the preparation of typical specifications for oils, asphalts, and tars for various uses. Among the laboratory investigations now under way may be mentioned a study of volatilization tests for road oils and asphalts with reference to the amount of loss and the effect produced upon the residue. An investigation of the density and toughness of various bituminous aggregates is also being conducted, as well as one upon the effect of exposure on different bituminous materials.

A small experimental refining plant has been installed at Arlington Farm and an investigation of various refining processes is being conducted on typical crude petroleums which are used in the manufacture of road materials. At the present time there is available very little exact information upon the details of manufacture of petroleum products, the limitations of the various methods of procedure, and the final products which may be commercially obtained. Information of this character is very desirable, if not essential, in the intelligent selection of bituminous road materials and the preparation of specifications to secure the desired product.

FOR A PAVED ROAD SYSTEM.

Maricopa County, Ariz., by a vote of 14 to 1, favored a bond issue of $4,000,000 for road construction. The proceeds are to be used in the building of a paved road system.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Application for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free. In applying for these publications the name of the series as well as the number of the publication should be given, as "Bureau of Public Roads Bulletin No. 32."

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

OFFICE OF PUBLIC ROADS BULLETINS.

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
32. Public Road Mileage Revenues and Expenditures in the United States in 1904. 15c.
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DEPARTMENT BULLETINS.

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction of the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913
136. Highway Bonds.
220. Descriptive Catalogue of Road Models of Office of Public Roads.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
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347. Methods for the Determination of the Physical Properties of Road-Building Rock.
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387. Public Road Mileage and Revenues in the Southern States.
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389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A summary.
393. Economic Surveys of County Highway Improvement
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests
555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials.
583. Report on Experimental Convict Road Camp, Fulton County, Ga.
586 Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916

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Dept. Bul. 660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916 and 1917.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads

OFFICE OF PUBLIC ROADS CIRCULARS.

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Preservation. and Road Construction 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98 Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

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65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
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74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETINS.

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

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Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
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REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
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Vol. 11, No 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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Public Roads

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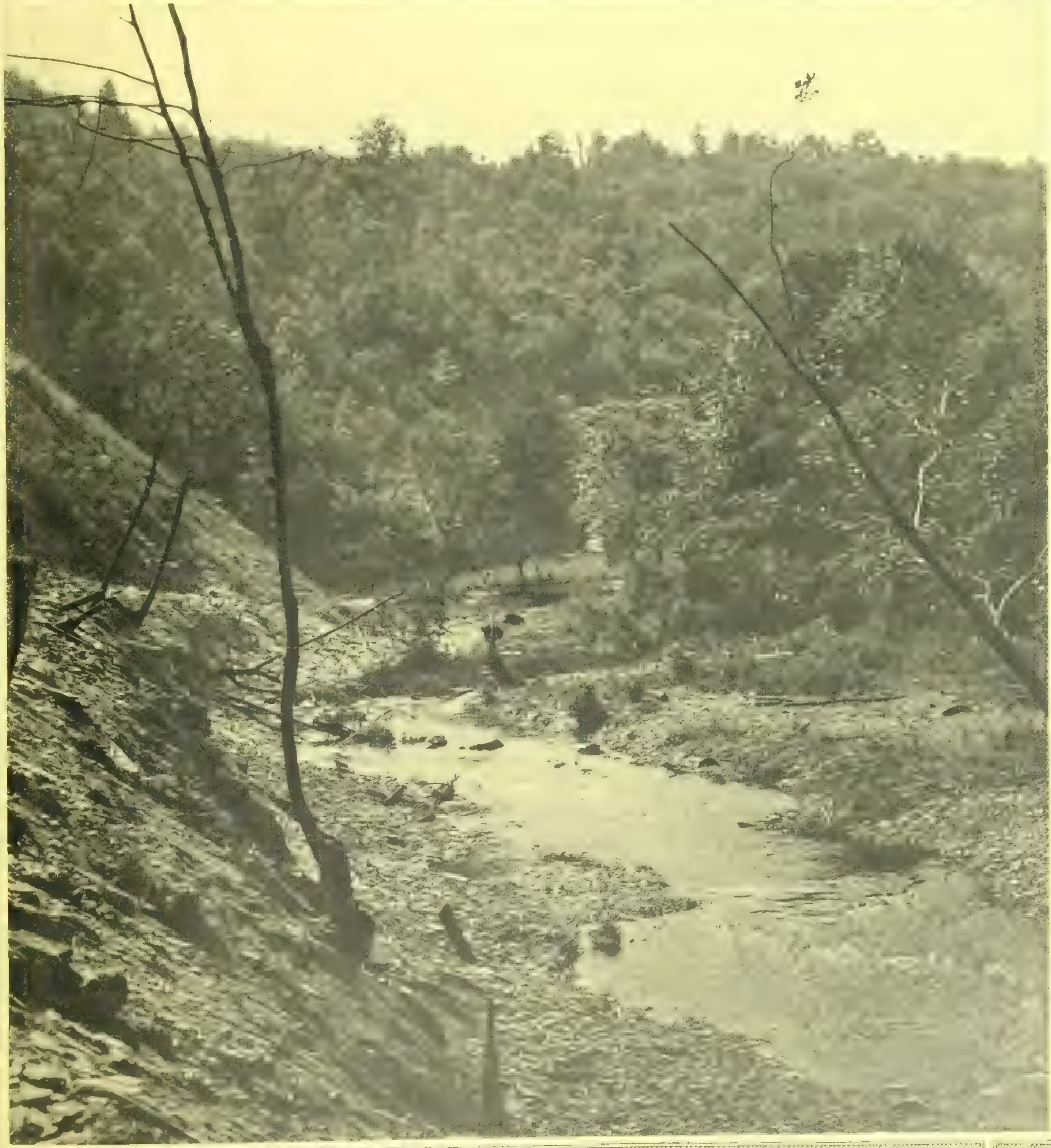

TYPICAL COUNTRY THROUGH WHICH PENNSYLVANIA No. 12 RELOCATION WAS MADE

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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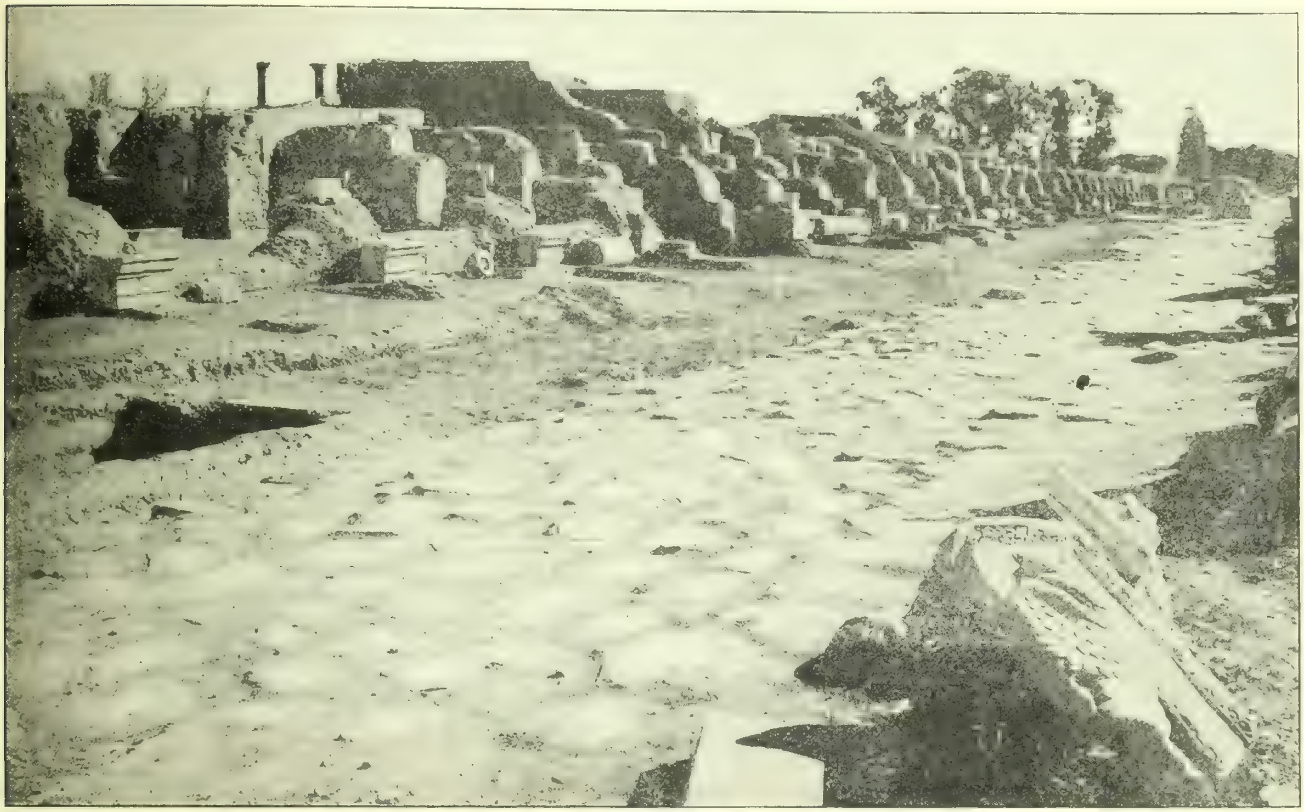
GRANITE BLOCK CONSTRUCTION.

By JULES L. GOLDBERG, Chief Editorial Division, Bureau of Public Roads.



PORTION OF THE APPIAN WAY, DECAYED AND NEVER REPAIRED, THOUGH MAJOR PART OF HIGHWAY, NOW 2,000 YEARS OLD, IS IN GOOD CONDITION.

THE history of stone block pavements begins back in the days of King Menes, who built a road 10 inches thick to the Pyramids. Later, in the early days of the Roman Empire, stone pavements were constructed of large flags, with the smooth face turned up. The spaces between these large stones were chinked with smaller stones, bedded in mortar. The historic and famous Appian Way is probably the greatest example of this type of pavement ever constructed. This road, in general, is in reasonably good condition to-day, considering the fact that it has been in use for more than 2,000 years.

The earliest stone pavements in this country were composed of cobble stones taken from benches or gravel beds, laid in sand and the joints filled with gravel or sand. The old city of Panama in the time of the buccaneers, when Morgan, the pirate, destroyed the city in 1680, had streets paved in this manner, good examples of which may be seen among the ruins to-day. In many of the cities in the United States there are remains of these cobble-paved streets that were laid more than 100 years ago. In many cases these old cobble-stone pavements have formed the base for sheet pavements of various types and materials, making in this manner a durable smooth pavement, many years after the original construction of the street, without relaying.

APPROACHING THE MODERN TYPE.

Finally, it became desirable to obtain a flatter, smoother surface for the top of the paving, and the quarry split blocks began to come into use in the vicinity of all centers where granite quarries were in operation, and gradually spreading to the larger cities. In earlier times in this country, owing to the fact that vessels were loaded with rum, molasses, and cotton from the South for shipment to New England points, a considerable industry was created through the necessity of ballast for return loads, and the holds of the vessels were loaded with the old-style granite blocks as ballast for return trips to the South. These old flagging pavements are in existence to-day in many Southern Atlantic and Gulf cities. The blocks used in that period generally were from 12 to 18 inches in length, 12 inches in width, and 6 to 8 inches in depth. These were laid on the graded natural subsoil on a sand bed with sand joints.

That this was a very durable pavement is evidenced by the pavements still existing, particularly in the city of New Orleans, where many streets in the old section have this old type of pavement. These pavements show so little signs of wear that the material would lend itself very readily to the production of a reasonably well-cut paving block, which could be used in making a first-class modern grouted pavement. The old-style pavement was naturally quite rough to travel over and the blocks would sometimes rock on their beds and tilt up.

UTILIZATION OF CONCRETE.

A theory was advanced later that if the block were smaller the surface would be smoother, and 6-inch cubes began to be used. But these were found not to be very satisfactory on account of not being able to break joints in a proper manner, and were followed with the old-style block, 4 to 7 inches in width, 9 to 16 inches in length, and about 8 inches in depth.

About 1880 came the realization that the blocks should be cut with less depth in order to save transportation charges, and in order to provide a smooth riding surface they should be made shorter in length. The reason for this was that it was felt that shorter blocks would more readily fit the contour of the crown of the roadway and it was thought that for the proper toe-hold for horses blocks 6 to 7 inches in width were too wide, so in order to cut down the expense of transportation concrete foundations were introduced and the use of a shallower block was begun.

Following the use of the concrete base at about 1888 the first examples of cement grouted granite block began to make their appearance in Massachusetts. This pavement was constructed on a 5-inch concrete foundation, 1-inch sand cushion. The joints were partially filled with peastone spread upon the blocks and broomed in previous to the rolling of the blocks, it being thought necessary at that time that the peastone should be incorporated in the joints in order to properly key up the blocks to hold them in place after ramming was accomplished. This method of laying later proved to be extremely disastrous owing to the fact that the grout in most cases stopped on coming in contact with the peastone and did not fill the joints from top to bottom as is done in present methods of construction. The old style block previously referred to was used in this construction.

SEEK INFORMATION ABROAD.

In 1905 New England quarry owners inspected paving laid in the city of Liverpool where the general custom was to use a 4-inch cube on a concrete base. This type of paving is what is now known in paving practice as Durax pavement, which is made in these times of small cubes varying from 2¾ to 4 inches in diameter, laid in concentric circles at right angles to the direction of travel. Many pieces of this style of pavement were laid in Germany, where they are known as Kleinpflaster. Many pieces have now been laid in this country, some examples existing in Washington where many short pieces are laid straight instead of in the oyster shell or concentric circle pattern. It has been the custom in many places, in connection with this style of pavement, where the granite blocks were of the old style, poorly-cut type, to use these old blocks remade into Durax cubes as a relaying proposition where such blocks were not of sufficient quality to admit recutting or napping into large size paving blocks such as is done in many cases. The 4-inch blocks in the city of Liverpool were giving good service and brought home more fully to them the realization that it was not necessary to cut and transport the deep 8-inch block, provided the concrete base was used underneath it. Consideration of this matter led to the production of the 4-inch block and the 5-inch standard block, in most common use to-day.

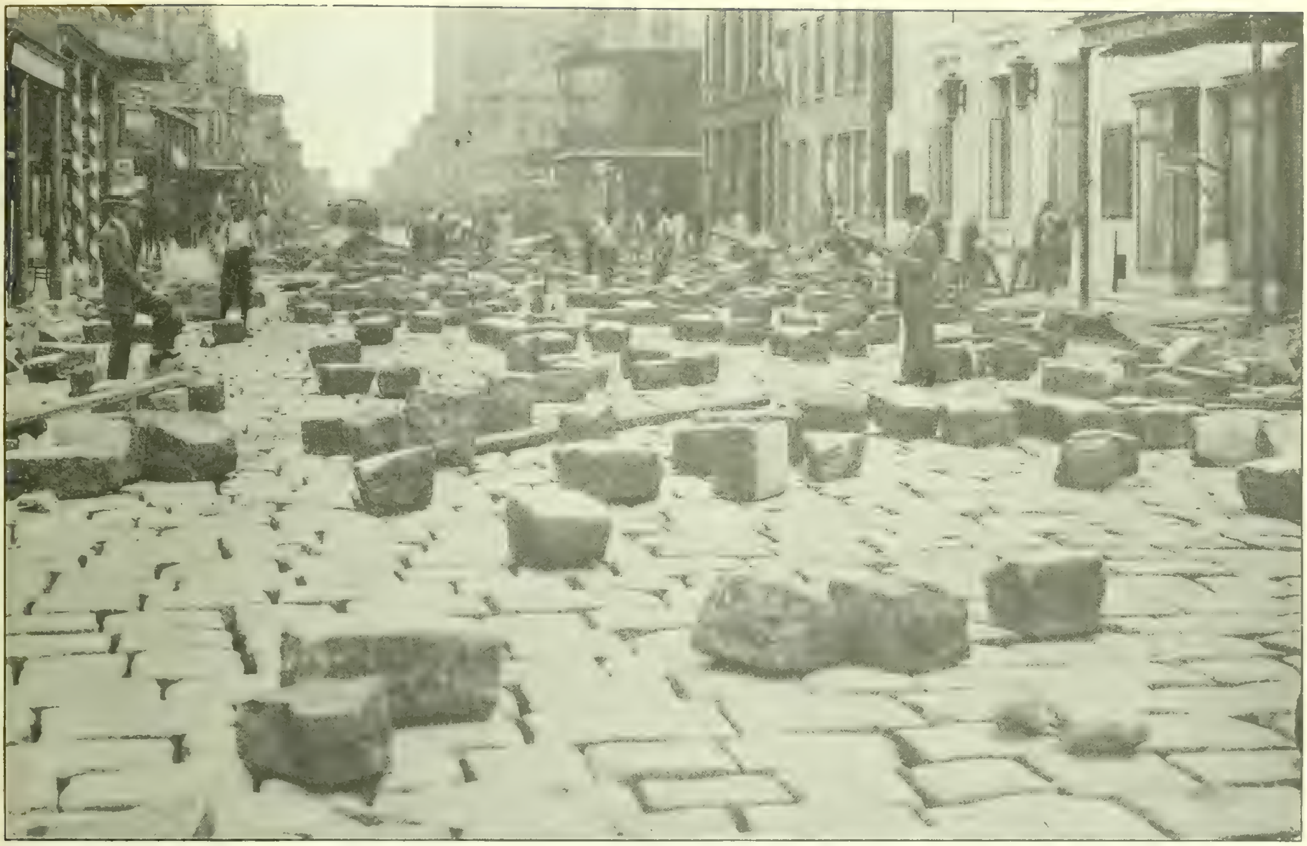
ENGINEERS DIFFER.

It was found in laying the 4-inch block in the manner customary at that time, which was with the addition of pea stone in the joints to steady the blocks in ramming, that if extreme care were not exercised in the use of the peastone, owing to the fact that the block was not very deep, the grouting (which had come into use at a little earlier period) did not get a proper hold and disastrous effects followed. This tended to develop the 5-inch standard block, giving a little more depth and a little more stability. This block is more generally used to-day than any other type.

The opinion of engineers varied materially in respect to the various sizes of blocks and many hesitated to change so radically from the original deep block to this later shallow block. Many of the engineers even preferred to use the old style blocks on a sand cushion with a grouted joint, rather than switch to the new shallow depth blocks with the concrete base. From the deep block, grouted, has developed the present trunk-line highway construction which is being advocated for use on many truck traffic lines using the block paved as above mentioned, but with the additional stability of being laid on a cushion base course consisting of one part cement to three parts sand, instead of employing the usual sand cushion on a well-compacted subgrade.

VARYING SIZES CAUSED DELAY.

The quarries were called upon to cut so many different varieties of blocks that they were unable to cut any size in advance for storage, with the result that many times jobs were held up owing to the fact that the blocks had to be custom made on order. In 1912 a meeting was held by a committee of the officials of various cities in order to standardize paving specifications and to endeavor to fix upon a special size of paving block, to be called the Standard Block. Even after this meeting the block was not universally adopted as was expected, and to-day the



OLD STYLE FLAGSTONE PAVING IN NEW ORLEANS.

manufacturers are turning out many different styles and sizes and grades of granite blocks known to the trade by various designations.

With many different sizes of blocks, it can readily be seen that great difficulty arose in production in advance of any amount of stock, as the producers hesitated to cut any quantity before knowing what particular sizes they would be called upon to deliver. No advantage whatever is obtained through variations in size, as with the "Standard" specifications for laying to-day, very little difference in durability or smoothness can be attained by deviating from the standard 5-inch or the 4-inch block in general use.

IMPROVEMENT IN CONSTRUCTION.

The improvement in the matter of construction has been very marked. The old flag-stone was replaced by the truer cut block, laid on sand or gravel, covered with a light coating of pebbles or sand, rammed and then covered a second time with a coating of sand which was broomed into the joints, forming the old style sand joint, which pavement, in its turn, disagreeably cobbled and made a rough riding surface. This was succeeded by a modification of the pebble and pitch joint, pebbles being broomed into the joints of the paving blocks, followed by a pouring of hot bitumen, filling the joints from top to bottom, which pavement also cobbled similar to the sand-joint block. This, in turn, was followed by the closely cut block laid in cement grout, making a true, smooth pavement; with a later modification of the bituminous mastic filler, composed of bitumen and sand, which made the pavement easier to open in case repairs to subsurface construction were necessary.

PREPARING THE BLOCK.

Classified under the trade name of granite are such allied rocks as monsonite, syenite, gneiss, and certain other igneous and metamorphic rocks. The granite occurs in nature in various shapes and forms. In some quarries it occurs in sheets with vertical joints. Naturally it would be expected that the grain of the stone would follow the bed and joint, but sometimes this is not true, the grain of the stone running diagonally across. In other quarries the stone was thrown up in its original shape, in an entirely different manner, being one great solid mass, without beds or seams.

In the manufacture of granite block no pressure or tendency to fracture is imposed on the stone at any time. Granite has a grain similar to wood, and splits readily on the natural lines of cleavage, differing from the case of crushed stone, where an enormous pressure is exerted internally in the production of the material in passing through the crusher. The paving block has been subjected to no internal strain, consequently to keep and preserve it in its original condition it should not be thrown from any great height in loading or unloading, which might

FIVE-INCH GRANITE BLOCKS RAMMED AND READY FOR GROUTING.

be apt to cause the conditions which have been avoided all through the manufacture, and which might also fracture the edges and corners of the stone, spoiling its proper shape. To further the interest of transportation and economy, the blocks, if possible, should be inspected at the quarry and all rejected material left there, rather than have it transported to the work itself.

TESTS.

The usual tests applied to determine the value of the paving block are, first, hardness; second, toughness; third, resistance to wear or abrasion.

(1) Test for hardness—that is, the resistance of the surface particles to displacement by abrasion—is usually determined with a Dorry machine. This machine consists of a circular steel disk, revolving horizontally, against which is held a cylindrical core of granite, cut from the sample to be tested by a diamond core drill, the cylinder being 25 millimeters in diameter, and is held perpendicularly against a disk under a constant pressure of 1,250 grams, while standard quartz sand, between 30 and 40 mesh, is fed onto the disk to act as the abrasive agent. At the end of 1,000 revolutions of the disk the loss in weight is determined and the test repeated with the specimen reversed. The average loss in weight computed from the two runs is used in determining the hardness of the rock. The following method of expressing the hardness has been adopted: Hardness, $H = 20 - \frac{W}{3}$. in which W = loss in grams per 1,000 revolutions.

(2) The toughness test as applied to paving blocks means the ability of the material to resist fracture due to impact. A cylindrical sample 25 millimeters in diameter and 25 millimeters in height is cored from the test piece by a diamond drill. The sample is then placed in the impact machine. The test consists of a 1 centimeter fall of a hammer weighing 2 kilograms for the first blow and an increased drop of 1 centimeter for each succeeding blow until failure of the test piece occurs. The number of blows required to cause failure is used to represent the toughness.

(3) The abrasion test: The Deval abrasion machine is used in testing the hardness as well as the toughness of the rock. The rock is broken into pieces as nearly uniform in size as possible. Fifty of the pieces, weighing in all 5 kilograms, are thoroughly dried before weighing, are then placed in a revolving cylinder and are given 10,000 revolutions at the rate of 30 to 33 to the minute. The per-

POURING ASPHALT MASTIC FILLER COMPOSED OF ONE PART ASPHALT AND ONE PART SAND.

centage of material worn off, or abraded, which will pass through a $\frac{1}{16}$-inch mesh seive is considered as determining the amount of wear. The amount of wear is expressed either in the percentage of the 5,000 grams used in the test, or else the French coefficient, which is in more general use, is given, viz, the coefficient of wear $= \frac{400}{W} = \frac{40}{\text{per cent of wear}}$, in which W is the weight in grams of the detritus under $\frac{1}{16}$ inch in size per kilogram of rock used. In this test the sample is thrown the length of the cylinder twice at each revolution, so that the individual stones grind against each other as well as against the sides of the cylinders. The rocks are likewise somewhat broken by the impact, so that the abrasion test can be considered as one not only for hardness but also for toughness.

CONSTRUCTION.

The original construction of the old cobble paving first used as a pavement was to excavate to the proper depth, which was fixed by the cobble itself. On this subgrade was placed a bed of gravel or sand; in this the cobbles were bedded with their longest dimensions vertically. Sand or gravel was then thrown over the top, a broom was used to remove the excess sand, leaving the head of the cobble bare, and the cobble was then rammed with a wooden paving rammer sometimes studded with steel plugs. As has been previously mentioned, examples of this work were found in the old city of Panama, and many examples are in existence to-day in cities in the United States, particularly Baltimore and Washington.

The next step in construction was the old flag blocks. These were bedded on a cushion of sand, rammed, and the joints filled with sand. Following these came the sand-joint block pavement, from which developed the granite block of to-day. This block was laid on a sand or gravel cushion, partially filled with sand in the joints, and then rammed; finally covered with a layer of sand, which, as it dried, was broomed into the joints. The pebble and pitch style of pavement was made by the use of screened pebbles of about $\frac{1}{2}$ inch in diameter, which were deposited in the joints, the paving then being rammed, and the final process was the filling of the joints with hot paving pitch by means of pouring pots.

A modification of this style of joint filling has been in use in recent years, asphalt usually being used as a joint filler, the pebbles and asphalt being placed in the joints in several layers with several pourings with the final finish a mat of asphalt and trap rock peastone.

TYPE FOR TRUNK LINES.

The method used in a number of instances, and which seems to be giving very good results, was to place on a well-compacted subgrade a cushion course of sand in which the blocks were paved, then rammed and grouted with a 1 to 1 cement and sand grout. If the 5-inch block of to-day is to be used in this style of paving, it should be paved on a cushion course of 1 to 3 dry cement mortar, instead of the sand cushion.

This last type of construction is being introduced for trunk line truck highway construction on through traffic lines and State highway construction.

On traffic highways it usually is customary to use a concrete base course varying in depth from 4 to 8 inches, constructed on a well-compacted subgrade. On this is placed either a cushion course of sand or of 1 to 3 or 1 to 4 dry cement mortar. On this the blocks are paved and rammed in courses of uniform width at right angles to the lines of traffic, using either the 4 or 5 inch block, and grouted with a grouting mixture of 1 part cement and 1 part sand.

Another type of filler used in connection with this style of pavement is that known as a bituminous mastic. This joint filler is composed of nearly equal parts of hot sand and hot bitumen, the proportion of sand usually running from 35 to 50 per cent of the combination. Whereas it is necessary in the use of the cement-grout filler to close the street to traffic for not less than six days after the grouting has been completed, where the bituminous mastic is used the street may be opened immediately upon the cooling of the bitumen, which takes place within an hour after the installation of the joint filler. Therefore where extremely heavy traffic congestion occurs it sometimes is advantageous to use the bituminous mastic filler. Also, in case of frequent openings in the pavement, it can be opened more easily than is the case with the cement grout filler. Naturally this type of pavement requires a very substantial concrete base to bridge over the soft spots and depressions and to sustain the mastic filled pavement.

PREPARING THE SUBGRADE.

In preparing the subgrade all soft and loamy spots must be excavated and filled with cinders or gravel, or other material proper for such purpose, and the entire subgrade then rolled and compacted by ramming and shaping to a true and uniform contour, care being taken that so far as possible no plowing or picking shall be carried below the final finished subgrade line. Proper drainage facilities should be provided either by ditching, tiling, or trenching.

The concrete base should be constructed of 1–3–6 cement concrete or better, the sand used to be clean, reasonably coarse and free from clay or loam, the stone used either clean graded crushed stone or clean screened cobbles, free from any rotten or disintegrated stone. The cement to be standard brand of approved quality, which will meet any of the standard tests called for in general construction work. The concrete should be mixed reasonably wet, but not so wet that the mortar will flow away after being deposited in the roadway.

SAND CUSHION.

Bedding sand should contain no particles which would be retained on a ⅜-inch mesh screen and should not contain over 10 per cent of loam or clay. If the concrete base has been allowed to set for not less than six days the sand and paving blocks may be carted in and dumped in windrows on the base.

This sand cushion may be substituted by a dry cement sand cushion mixed in the proportions of 1 part cement to 3 or 4 parts sand. This cushion should not in any event be mixed more than a half hour ahead of the time of using, and none of this material should be left over at the close of work and used again upon the resumption of work.

The blocks should be laid on this cushion course in courses of uniform width, as nearly as possible at right angles to the direction of travel. They should be rammed individually to a true and firm bearing, and under no condition should they be rolled with either a hand or steam roller, as rolling will force the bedding material up between the joints, and rock a block on its cushion. As the blocks are not of uniform depth the roller would only strike on the high, deep blocks, without ramming the shallow blocks at all. All low blocks after ramming should be raised with paving tongs, no pinch bars being used, as pinch bars usually dislocate surrounding blocks as well as the one which it is desired to lift.

READY FOR GROUTING MATERIAL.

The ramming should be done with a rammer weighing from 25 to 50 pounds, with a steel base. After the blocks are properly rammed they are ready for the grouting material, which usually is a cement grout mixed in the proportions of 1 part cement to 1 part sand, the sand being of such fineness that no particles should be retained on a 20-mesh screen and not over 10 per cent of it pass a 100-mesh screen. The cement should be any well known brand Portland cement that will meet standard specifications for such material. The grout should be mixed thin enough to run freely to the bottom of all joints, but thick enough so that it will not run away in the flow line of the street.

Before the initial set takes place a second finish coating of grouting should be applied, filling the joints flush with the blocks. The whole should be broomed, first with a street broom to remove the surplus grout from the top of the blocks, and finally

POURING JOINTS WITH ASPHALT FILLER BY POURING-POT METHOD.

finished by the application of an ordinary bristle house broom, leaving the whole surface smooth and uniform. The finished surface should be protected from the weather by frequent sprinklings and by the addition of a thin layer of sand or dirt, which should be dampened, applied to the top of the pavement after the first set has taken place.

A barrier should be erected to prevent traffic from entering upon the work, as any trespass at this time means a sacrifice of the paving. Once the grout has broken it never can mend. Watchmen should be provided for 24 hours per day, if necessary.

The application of the bituminous mastic grout follows along practically the same lines as the cement grout, the bitumen being heated in kettles and the sand-heating plants or over pipe heaters. After the bitumen has been drawn into wheel-barrows, the hot sand is added, the two ingredients mixed with a steel squeegee and the mass then dumped upon the pavement, running down into the joints, as much as possible of the mastic being squeegeed from the top of the blocks while it is hot.

MAINTENANCE COST LOW.

While the initial cost of granite block construction is high the maintenance of the pavement, if properly laid and grouted, is less than that of almost any other type of pavement. In the city of Worcester, Mass., over a period of ten years the average cost per yard was $0.00415. This also is true in other cities regardless of the fact that in general the streets covered with granite block paving are those carrying the most severe traffic of any. And in considering maintenance cost it should be in connection with the amount of traffic.

City of Worcester, Mass., statistics on granite block paving (new blocks on concrete foundation with joints and surface grouted with cement).

MAINTENANCE COST FOR 10 YEARS ENDING NOV. 30, 1918.

Year.	Maintenance cost.	Yardage existing in city at date indicated.	Cost per yard.
1918	$738.72	261,048.6	$0.0028
1917	2,563.03	255,934.8	.01001
1916	910.62	252,270.2	.0036
1915	806.33	265,246.6	.00303
1914	857.30	237,292.0	.0036
1913	1,091.66	229,313.3	.0047
1912	406.87	219,868.3	.0018
1911	1,167.66	185,402.5	.0062
1910	806.90	160,025.6	.0050
1909	29.63	33,805.9	.0008
	[1] 9,378.72	..	[2] .0415

[1] Divided by 10=$937.87 average maintenance.

[2] Divided by 10=$0.00415 average cost per yard for maintenance per year.

GROUT MIXED BY MACHINE TO PROPER CONSISTENCY TO FLOW READILY TO BOTTOM OF JOINTS.

Usually in connection with different types of permanent pavements, if the workmanship and materials be right, very little trouble occurs so far as defects are concerned, but defects sometimes occur and their causes are enumerated.

CAUSES OF DEFECTS.

One of the defects most common is that occurring through the fact that the contractor has filled the joints nearly to the top with either sand or pea stone. Consequently, when the grout filler is applied it does not work down more than a short distance below the top of the block. The result is that the block is held in suspension by a narrow collar of grout around the top and around the bottom by pea stone or sand. The impact of travel on the top of the block drives the center of the block down, breaking the entire surface of the block away from the main block itself.

Difficulty usually is experienced where an excess amount of sand is used in the cushion course. In this case the excess depth of sand cushion in the bed seems to shift under the impact of travel and to compress more than the ramming of the blocks compressed it, in this way causing a slight settlement which is followed by the breaking down in the joints; although the blocks themselves do not break up in the same manner as when the narrow collar of grout is around the top. This difficulty, naturally, is more or less eliminated by the use of the 1 to 3 or 1 to 4 mortar cushion in place of the straight sand cushion.

Improper ramming is another cause of defects. When the blocks are not rammed home to a true bedding spaces are left underneath, affording the sand cushion a chance to shift its position after the pavement has been constructed and causing the joints to break down.

METHOD OF MIXING GROUT.

It has been proven by observation and by actual services that the 1 to 1 cement grout makes the most ideal joint filler so far as durability is concerned and a great many of the difficulties with granite block paving occur through the fact that a weaker grout than a 1 to 1 has been used in the construction. There are two methods in common use for mixing the cement grout joint filler. One is the hand-mixing method, using a box either tilted to one end or tilted to one corner, having a gate in the lower end which can be raised when the grout is mixed thoroughly. It is absolutely necessary, if proper work is to be accomplished, that the cement and sand shall be thoroughly mixed together first, and after the water has been incorporated that the entire mass be agitated constantly so that the sand will be

GRANITE BLOCK, GROUTED WITH 1 TO 1 CEMENT GROUT, WORN SMOOTH BY TRAFFIC.

afforded no opportunity for settling at the bottom, as the cement is lighter in suspension, and so that there should be in the mixture no lumps which would clog the joints.

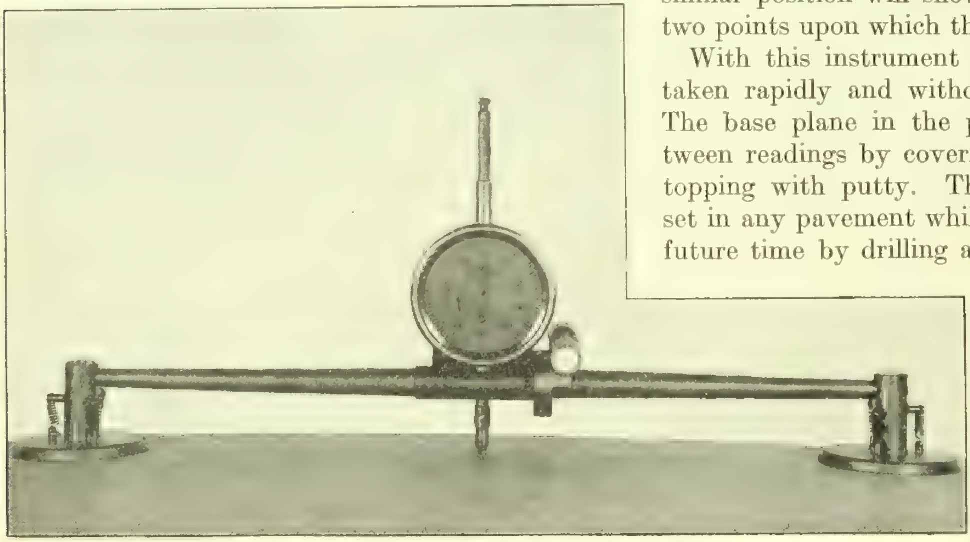
The other method of mixing is by machine. There are a number of different types of machines for this purpose, but all machine mixing in general is an improvement over the hand mixing method, owing to the fact that it keeps the grout much better agitated. There is more chance to obtain poor work through improper mixtures of the cement grout than through improper mixtures in the bituminous mastic grout for the reason that whereas it is extremely easy to mix any proportion of cement and sand together up to about 1 part cement and 5 parts of sand and agitate sufficiently so that it can be poured into the joints, filling them easily; it is much more difficult to incorporate sand in the bitumen in excess and get it to run into the paving joints, for the reason that any proportion more than that of equal parts of sand and bitumen becomes so stiff that it is incorporated with difficulty in the joints and easily shows to the eye that the proper proportions have not been used in the mix.

Hardly any paving material outside of old worn-out macadam roadways lends itself to salvage to such an extent as granite block. Old blocks transported to Southern ports many years ago if recut into granite blocks now would more than cover the street areas where they are. The same is true of most of the old-style large blocks which were used in the earlier days of block production. In this case the method pursued would be to trace a line across the center of the block, the block then being struck a sharp blow on the opposite side it breaks in two, forming two blocks nearly of the standard size, which could be used with the new face turned up, forming a new, fresh granite surface built of old blocks napped in the manner described. If the blocks are cobbled on top through excessive wear they can be recut or trimmed on the sides, eliminating the cobbled effect, and still making use of practically the entire block. If the blocks are not suitable for napping or recutting, there is still another salvage value, for they may be cut into small Durax cubes so that regardless of the length of time they have been in service there is a salvage value until they are completely worn out or broken up.

INSTRUMENT FOR MEASURING WEAR OF CONCRETE AND OTHER SURFACES.

By W. E. Rosengarten, Highway Engineer, Bureau of Public Roads.

THE design of our highways is becoming more and more an exact science and detailed data on various phases is urgently needed. A factor which should be known to intelligently decide on a particular material or method of construction is the life of the resulting pavement. One of the important elements in determing this is the rate of wear of the road surface.

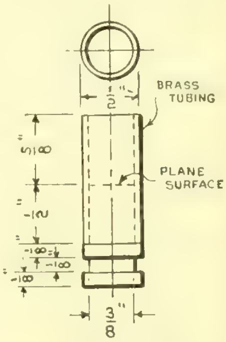


An attempt has been made to measure the wear caused by traffic. The instrument shown in the accompanying illustration was designed and made in the Research Division of the Bureau of Public Roads under the direction of A. T. Goldbeck. It consists essentially of two bearing plates each 2 inches in diameter, pivoted on universal joints to a spanner 11½ inches long. At the midpoint is mounted a micrometer, whose plunger has a travel of 1 inch, and whose dial is graduated to read to 1/1000 of an inch. A level bubble indicates when the plunger is vertical.

In order to form a base to which measurements can be referred from year to year, brass plugs, as shown in the accompanying sketch, are set in the pavement where readings are desired. Readings are taken by resting the bearing plates on the road surface and allowing the spindle or plunger to rest on the base plane of the plug. The instrument is plumbed with the aid of the level bubble, the spanner bar being held parallel to the center line of the road. Another set may be taken with the bar at right angles to the center line of the road. Additional sets may also be taken if desired by placing the bar at other angles with the center line of the road. The difference in readings taken in later years in a similar position will show the average wear at the two points upon which the bearing plates rest.

With this instrument accurate readings may be taken rapidly and without interruption to traffic. The base plane in the pavement is protected between readings by covering with cotton waste and topping with putty. The brass plugs are readily set in any pavement while it is being laid or at any future time by drilling as small hole with star drills and setting the plug in cement grout. The purpose of the groove near the base of the plug is to give a good bond with the pavement. These plugs do not affect the pavement, are not injured by traffic and may be set in a concrete pavement at the rate of 30 or 40 per man per day.

Readings on the wear of concrete road surfaces are being taken on the Chevy Chase Lake Road, Montgomery County, Md., and the Camp Humphreys Road, Alexandria County, Va. Five plugs are set across the road at a section. It is hoped to determine from these and other readings the relation between wear caused by traffic and the per cent of grade, the compressive strength of the concrete, the kind of aggregate, the method and type of construction, etc. It is proposed to start readings on other projects so that considerable data may be collected not only on concrete but on brick, macadam and other classes of road surfaces. Detailed blue prints of the instrument will be gladly furnished to anyone applying to the Bureau of Public Roads, Washington, D. C.



BASE PLUG
Brass

CONSTRUCTING PENNSYLVANIA FEDERAL AID PROJECT NO. 12.

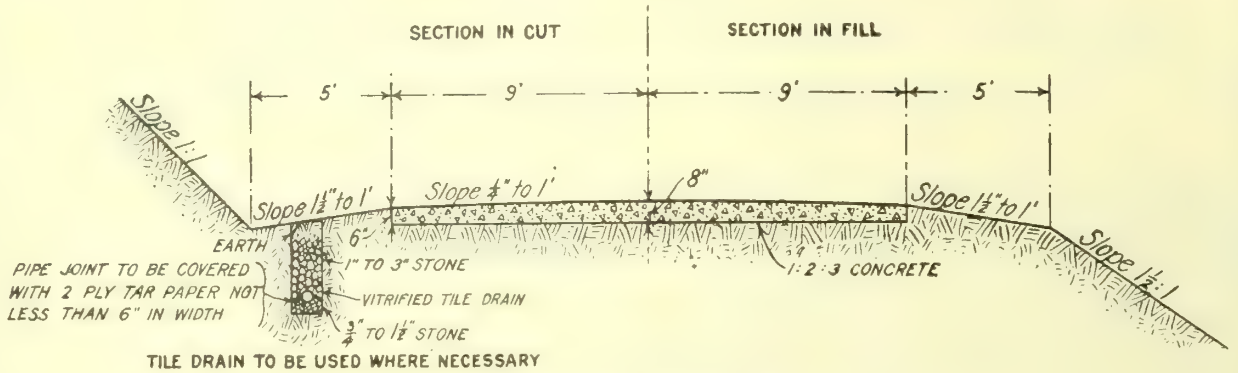
ROAD RELOCATION TO ELIMINATE GRADE CROSSING.

In order to secure the high standard of excellence which is the desire of all who are dealing with Federal Aid Highways, the highest standards should prevail at all stages in the development of every project. This implies high standards in location, and in design as well as in methods of construction and it is possible that from this description of the work done by the Pennsylvania State highway department, on project No. 12, highway engineers may devise some material benefit.

LOCATION.

This project is located between Marten's Creek and the Bangor Boro line, Northampton County, Pa., and is 5.45 miles in length. In general the location follows an old right of way between these two points but the original alignment has been greatly improved, sharp curves eliminated, reasonably long tangents introduced and, wherever the alignment required, entirely new locations selected. Two of these new locations are significant of the advanced ideas now prevailing in highway design. The first shows the new location in the foreground and the old road in the distance, the railroad lying between. This relocation was made for the purpose of eliminating two grade crossings, a most important matter in modern highway location. The new location takes advantage of a high railroad crossing over a small creek, at which point it passes under the company's rails. This appears to be an excellent solution of the problem of grade crossing elimination and one which could be adopted more frequently.

The second significant relocation is one made to save distance as well as to improve alignment. Hard surface pavements are expensive. On this highway, the surfacing alone costs $6 per lineal foot of highway. Where such costly pavements are used, savings in distance may be rather expensive as to excavation and as to right of way costs and still show material net savings in total cost owing to the high value of the paving which is eliminated. A slate hill had to be cut away in order to make one of the relocations and the cover illustration shows the general nature of the country traversed but even under such adverse conditions as these,



TYPICAL SECTION
PENNSYLVANIA FEDERAL AID PROJECT NO. 12

extensive changes in alignment are justified if the saving in pavement cost which results is greater than the cost of the increased earthwork. The new location used on this project is clearly shown by the loose rock which has been drilled and blasted and now lies ready for the shovel.

Other important features in the location of this road might be mentioned but aside from a statement that great care has been exercised to secure the proper adaptation of the line to local drainage features, they need no special mention in this connection.

DESIGN.

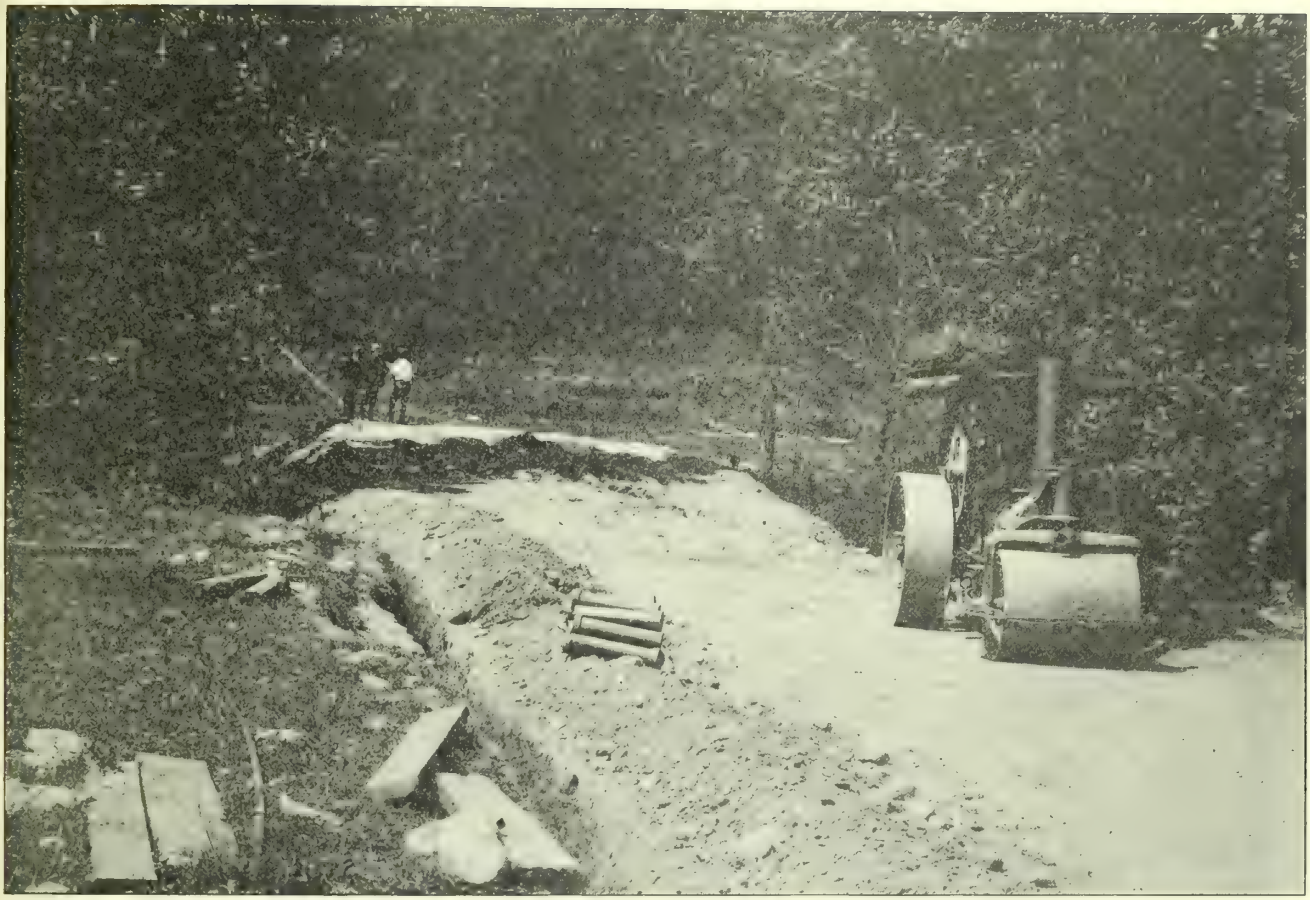
It is no idle remark to state that the design of a road begins with its location, and this was the case with the design of this highway. However, to treat the subject in more ordinary fashion, the salient features, particularly those not common to highway design generally, will be considered as matters of design rather than as a combination of location and design.

The first of these features is the use of short uniform gradients, frequent breaks in grade, and long vertical curves. In laying the grade line, highway engineers quite generally use long uniform gradients and short, vertical curves, an evident adaptation from railroad engineering which, almost always, results in producing heavy excavations and heavy embankments. In refreshing contrast with this custom as to laying in the grade line one finds, on this project, every evidence of a distinct effort to reduce both the cuts and the fills to a minimum by a careful and well thought out policy as to maximum grades coupled with the use of short uniform gradients, frequent breaks in grade, and vertical curves fitted to the original ground surface. In so proceeding there is evident not only the idea of effecting a valuable saving in earth work, but also of adhering to a cross-section which has in it a minimum of the element of danger to rapidly moving traffic.

The adjustment of the grade line on this project has also been influenced by the fact that, speaking generally, hard surface pavements have given more trouble on deep fills and deep cuts than where the original ground surface has been only slightly disturbed. This subject would by itself admit of extended discussion, but it is sufficient to mention it in this connection, and to note that the evidence so far produced justifies the impression that, aside from such work as is necessary to keep within whatever maximum grade has been established, on this project 6 per cent, the less cutting there is done the better both from the standpoint of the safety of the pavement and of the traffic passing over it.

The cross section adopted may also be worthy of careful study. It is the ditchless cross section and is advocated by those who have a keen appreciation of the element of danger to fast moving traffic which is found in the more common cross sections a major feature of most of which is a heavy ditch. Extensive tile drainage and careful maintenance are the two factors that control the effectiveness of this section, and both are adequately provided for in this State.

The dimensions of the concrete surfacing deserves a word of comment. It now is generally recognized that an 18-foot width of surfacing is the standard for two-way traffic. The fact, however, that this highway is located in a country district where the present traffic is light and the prospective traffic not by any means heavy, when coupled with the fact that this width has been adopted indicates the farsighted policy which is at the basis of highway design in this State. The same may be said as to the thickness of the surfacing and as to the mix, an 8-inch (center) concrete pavement of a 1–2–3 mix being indicative of a keen appreciation of the traffic which all pavements must ultimately carry.



ROLLING THE SUBGRADE.

CONSTRUCTION.

The construction of this highway was let for approximately $320,000. Work was begun immediately upon letting and is progressing favorably.

The first impression that one obtains on viewing this project is of the effective use which is being made of modern machinery throughout the job. Light jack-hammer drills are in use wherever rock is encountered. A steam shovel handles all earthwork, the earth being taken out with unusual accuracy. Not a dollar is lost by inaccurate cutting which must, later on, be shaped up and realigned. This is of no little importance, for carelessness in taking out earthwork with consequent alterations and readjustments of slopes, all of which must be done by hand, are a common cause of serious loss to road contractors.

The specifications for this project require that the fill shall be rolled in layers. All of the features illustrated the use of modern machinery in modern highway construction with the consequent elimination of human labor. Still though there are good machines at work on all phases of this work there is no surplus equipment. Every piece of equipment is in the right place, and is being used in the right way. No money has been squandered on needless machinery.

HANDLING OF MATERIALS.

But in spite of the efficiency with which other parts of the work are being conducted the most radical and the most interesting departure from customary procedure is in the handling of the materials for the concrete itself. These materials are delivered by rail on the siding. They are unloaded by a locomotive crane which operates a clamshell bucket, and dumped onto the material piles which lie over the hoppers. A light industrial track, laid on a gravity grade, runs under these hoppers, which are so built that six buckets can be loaded at once, the operation being carried on as follows:

The engine delivers a train at the top of the gravity track. Six cars are then cut loose and moved by hand so that the first bucket of each is under its stone hopper. The hopper is then opened and stone compartment of the first bucket on the car is filled. The 6 cars are then moved forward till the second bucket comes under the chutes and the stone compartments in these buckets are filled. The 6 cars are then shoved forward and placed under the 6 sand chutes. In two operations the 12 sand compartments are filled and the cars are then pushed on to the 3 cement chutes where the cement compartments are filled. The whole

MAKING LOW COSTS WITH PROPER MACHINERY AND CAREFUL WORK. NOTE ACCURACY OF SIDE SLOPES, AND EXCAVATION FOR TILE DRAINS.

operation uses 9 men and filling 6 cars (12 full charges for the mixer) takes about five minutes.

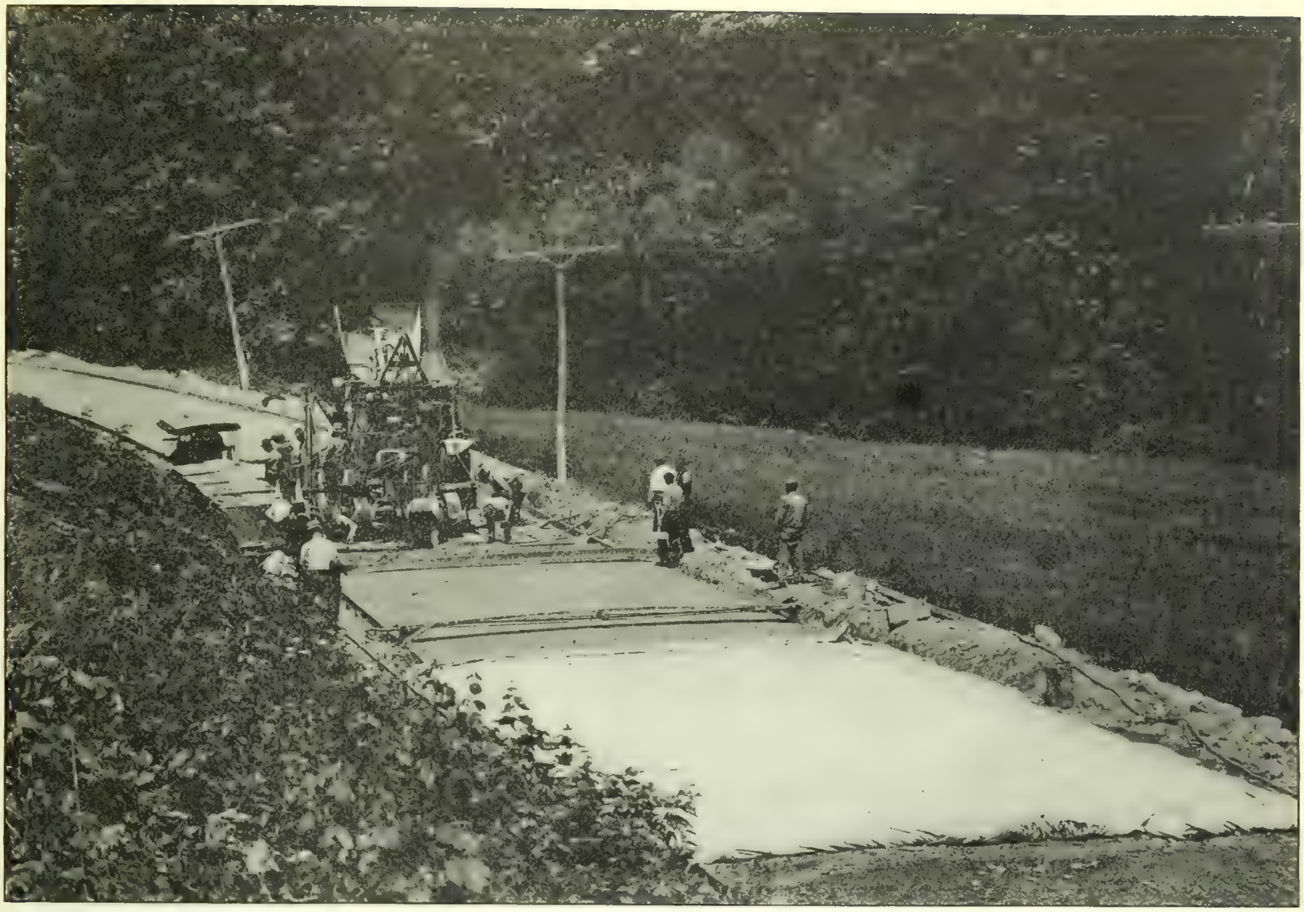
In the meantime the engine has picked up another string of the cars, this string having been loaded while the engine was at the mixer, and starts for the mixer. Near the mixer there is a switch where this train lies till the mixer has handled the material delivered to it by the alternate train. When this alternate train pulls out, the first train pulls in with its load and lies at the mixer until its load is used up. In this way two engines handling three strings of cars can keep a large mixer operating at full capacity up to a distance of about 6 miles between mixer and loading bins and on a good track can be operated over grades of 6 to 8 per cent.

A general view of the plant in operation and the small number of men engaged around the mixer can not but impress everyone familiar with concrete pavement construction. This cut also gives a splendid view of the proper protection of recently placed concrete, the earth-covered pavement appearing in the immediate foreground with the canvas-covered slab, just laid, immediately beyond.

By handling materials in this way something over 400 feet of pavement is being laid per day, and while the economies which this plant develops must be the great argument for its more general adoption, the fact remains that, from the standpoint of the technical expert, the entire absence of any disturbance of the prepared subgrade, and the entire absence of those rehandling processes which are so apt to more or less contaminate the aggregate by the inclusion of earthy material, will present themselves as very potent reasons for the more general adoption of such systems as this for delivering the materials used in concrete road construction.

INDEPENDENT OF WEATHER CONDITIONS.

Another important consideration which should influence the more frequent selection of this system of handling materials is the fact that it is almost entirely independent of weather conditions. Road improvements, even those involving the use of a high type of surfacing on a general route formerly covered by a gravel or a macadam surface, involve enough widening, reshaping, and realigning of the subgrade so that the movement of materials has to be stopped not only during rain storms, but for a considerable period thereafter. A moist subgrade is not, however, any hindrance to the actual laying of the pavement itself. Therefore, except during the time when rain is actually falling, this outfit can be operated to the capacity of the mixer, and the average rate of progress made is therefore high.



GENERAL VIEW OF PLANT IN OPERATION. NOTE METHOD OF COVERING CONCRETE.

The extent to which labor has been saved on this project has nowhere been better illustrated than in obtaining a feed water supply for the locomotive crane which unloads the aggregate. To provide the necessary water an old tank wagon was mounted on a platform, a hydraulic ram set in a nearby creek, and the two connected by a pipe line. Since that day, and without further attention, this makeshift tank has never been short of water. It is by such savings as this that construction jobs are made to show a profit.

The proof of the advantage of any method of construction lies in the results secured. On this job the layout in plant is not excessive; indeed it is rather below the average for jobs of this size. However, since concreting began the mixing plant has worked 30 days out of 31 working days (data to Aug. 15), has averaged 240 feet of 1-2-3 concrete pavement 18 feet wide and an average of 7.33 inches thick per day with a force of 8 men on the mixer, 6 men on the material piles, and 4 men on the trains. This compares very favorably with the personnel usually required to accomplish this amount of work. Those who wish to use these figures for making comparisons with the personnel on other oing jobs will, of course, remember that the men on the trains and at the storage piles are not a part of the mixer crew, but correspond to the personnel engaged in delivering material on other jobs.

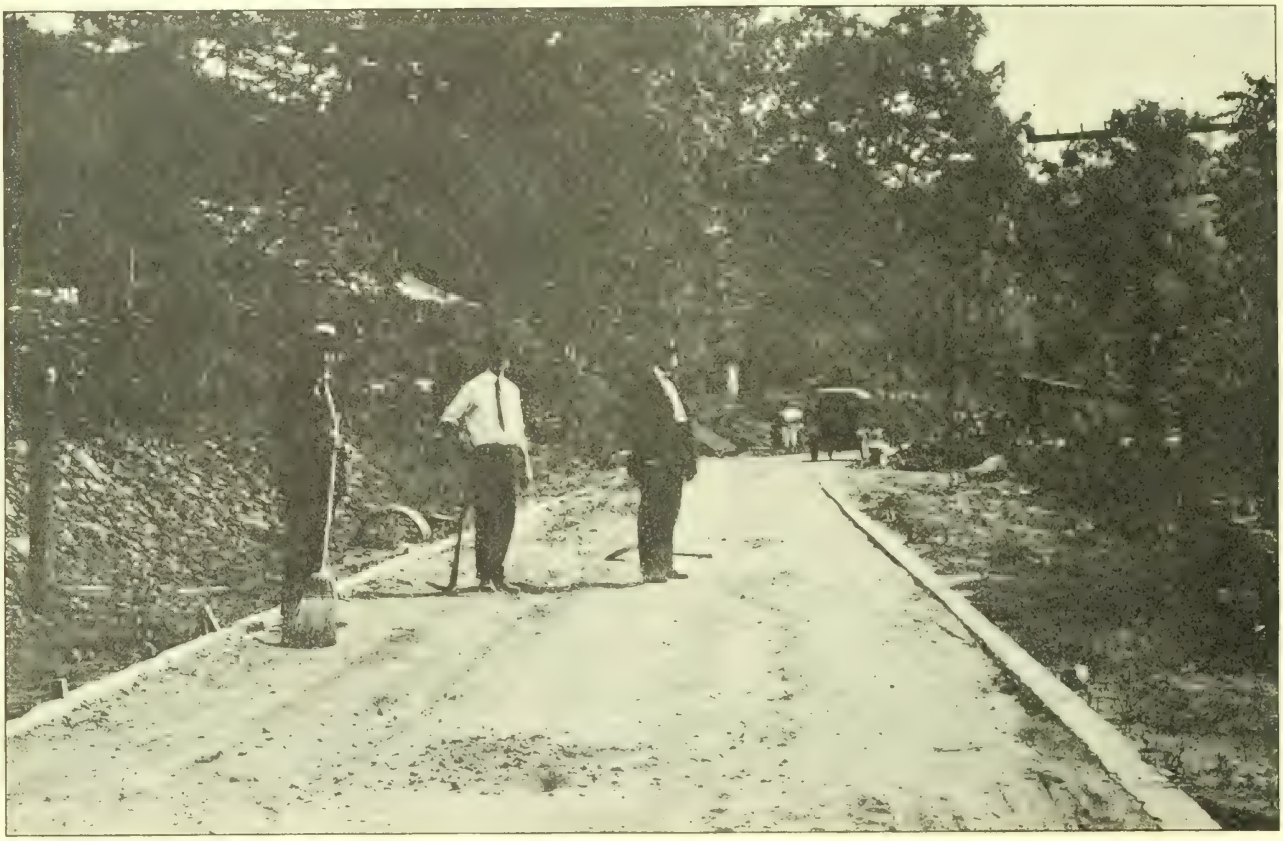
CITY CONTRIBUTES FOR ROADS.

The New York Commission of Highways let a contract in August for constructing a highway 4.03 miles connecting the village of Carrollton, Cattaraugus County, with the city of Bradford, Pa. Thi road will cost $153,344.

In order to insure the building of the road connecting the New York town with Pennsylvania the Bradford Chamber of Commerce raised $90,000 as the city's share of the cost, establishing a unique precedent in financing highways connecting two States. The road will be of concrete and will cost about $33,300 a mile.

Commissioner Greene of New York obtained the consent of Secretary of Agriculture Houston for the road to cross the Allegany Indian Reservation. The Secretary also approved changes in the original plans which eliminated three grade crossings, saving to the State of New York $70,000. When the road is completed the citizens of Bradford will hold a celebration.

WHAT FROST DOES TO CONCRETE.



AS cold weather approaches the problem of so laying concrete pavement that it will not freeze becomes a serious one. The above illustration shows the result of laying a concrete base in such cold weather that the methods adopted for its protection failed and the concrete froze. It became necessary to build a new base and integral curb over the old one.

It sometimes happens that concrete roads must be laid during cold weather, but the practice is always attended with risk and should be avoided unless most urgent necessity requires immediate construction in spite of weather conditions. It is better to stop laying concrete a little early than to stop a little late.

ROAD BONDS IN MISSOURI.

Missouri counties which have voted road bonds, which are to hold bond elections or in which bond issues are being agitated include the following: Greene, $2,000,000; Laclede, $250,000; Texas, $225,000; Howell, $500,000; Jasper, $250,000; St. Francis, $1,000,000; Franklin, $1,000,000; St. Louis, $3,000,000; Phelps, $400,000; Warren, $400,000; Dunkin, $23,000; Butler, $500,000; Buchanan, $2,000,000; Scott, $1,000,000; Oregon, $300,000; Stoddard, $200,000; Ripley, $120,000; Wayne, $30,000; Gentry, $100,000; Clay, $100,000; Harrison, $113,000; Cole, $300,000; Livingston, $1, 250, 000; Atchison, $1,000,000; Andrew, $1,250,000; DeKalb, $1,250,000; Clinton, $1,250,000; Ray, $1,250,000; Nodaway, $2,000,000; Daviess, $1,000,000; Carroll, $1,100,000; Sullivan, $1,000,000; Putnam, $750,000; Marion, $1,500,000; Adair, $750,000.

Special road districts throughout the State have also voted large amounts of bonds.

OREGON ROAD BUILDING.

During the first seven months of this year the state highway commission of Oregon spent $1,714,343. Contracts have been awarded for more than 1,000 miles of road, at an estimated total cost of $16,903,361. These roads, including work on 20 different highways, will be made up of 370.1 miles of paving, 193.8 miles of macadam, and 528.6 miles of graded roads.

BIG ROAD PROJECTS INCLUDED IN JULY AND AUGUST APPROVALS.

FEATURES of the Federal-aid record in both July and August were three road projects to cost over $1,000,000, one of them over $2,600,000, and the large total amount of improvements covered by the projects submitted in several States.

In both July and August the number of Federal-aid projects approved showed a decline from the high record set in June, and there was a decrease in both the estimated cost of the roads and the Federal aid allowed.

The falling off does not indicate any decrease in the road-building activities throughout the country. The June business was probably greatly increased by efforts made by various State highway departments to rush in many projects for approval before the close of the last fiscal year, ending June 30.

There was a decrease in the projects signed by the Secretary in July from the previous month. In August agreements executed showed a large increase over the July figures and were much above those for June. In agreements signed the August figures make a new high record.

Up to and including August 31 the total number of projects approved was 1,583 and the project agreements executed by the Secretary of Agriculture 826. The approvals covered 15,124.82 miles of road, whose estimated cost is $172,248,883.66 and the Federal-aid allowance is $70,800,791.39. The agreements covered 6,908.34 miles, for which Federal aid was allowed to the amount of $32,069,204.81 on an estimated cost of $75,314,016.37.

FEDERAL AID IN JULY.

In July 144 Federal-aid projects were approved, there were 5 revisions, and 6 statements previously approved were withdrawn. Approvals, covered 1,268.07 miles of road, estimated to cost $20,682,523.37, for which the Federal-aid allowances amounts to $7,193,942.85. The withdrawals covered 44.81 miles, with an estimated cost of $129,629.77 and an allowance of $50,700.

During the month 58 agreements for Federal aid were signed by the Secretary of Agriculture, while 15 agreements previously signed were modified, with increases in the amount of Federal aid allowed. These 73 agreements covered 413.045 miles of road, the estimated cost of which is $6,296,370.91 and the Federal aid allowed $2,671,356.46.

In the July projects approved hard-surface roads represented slightly less than one-third of the total mileage. Earth, sand-clay, gravel and macadam roads aggregated over 800 miles.

PENNSYLVANIA'S PROJECTS.

Pennsylvania occupied first place in the record of statements approved during July in number and in the amount of Federal-aid allowance and in the estimated cost of the roads to be constructed, while Nebraska turned in the greatest mileage. Seventeen projects in Pennsylvania approved will cost $4,607,028.41, for which the Federal aid is $1,968,997.40.

Ohio with 12 projects came next to Pennsylvania in the number approved and in the estimated cost of the roads to be improved and third in the amount of Federal aid. The figures are, respectively, $1,959,691.12 and $615,800. Oklahoma's two projects occupy third place in the estimated cost of the roads and second in the amount of Federal-aid allowance. The cost is estimated at $1,771,555.64 and the amount of Federal aid, $850,000. Washington with 10 projects is the only other State whose estimated cost exceeds $1,000,000 for the month. On a mileage of 57.498 the aggregate cost is estimated at $1,215,433.36 and the Federal aid $607,761.65. Indiana with 2 approvals and 2 revised projects, with an aggregate mileage of 25.92, fell just below the million-dollar mark in the estimated cost of roads, $940,876.81, for which the Federal-aid allowance is $464,612.19.

In Indiana the ratio of Federal aid requested and allowed was a little over 25 per cent of the cost of the roads, in Ohio less than 35 per cent, in Pennsylvania slightly more than 40 per cent, in Oklahoma almost 50 per cent, while in Washington it was exactly 50 per cent.

Nebraska, which was third in the number of projects approved, 11, has the greatest aggregate mileage, 233.20. Minnesota's 7 approvals aggregated 121.66 miles. Seven new projects approved and one revision in Texas aggregated 100.5 miles. One of the Nebraska projects is 56.9 miles long and another one 30.6 miles. A single project in Oklahoma was for 46.158 miles, a Minnesota project 38.5, and a Texas project 30. The average length of all projects approved during the month was 8.806 miles.

OKLAHOMA'S BIG PROJECT.

Oklahoma leads the country in the size of a single project handled in July. It is estimated to cost $1,271,555.60, for which $600,000 Federal aid is allowed. It is for 46.158 miles of concrete or bituminous road in Tulsa County. The third largest project is also an Oklahoma road—20 miles of concrete in Washington County, to cost $500,000, with Federal aid of $250,000. The second largest project is 13.24 miles of bituminous or concrete in Lackawanna and Wyoming counties, Pennsylvania, for which $304,616 Federal aid is allowed on an estimated cost of $609,232.80. Other projects costing large sums approved during the month include one for 7.14 miles of brick or concrete in Somerset County, Pa., to cost $457,065.50 and Federal aid to the amount of $147,071; and 6 miles of bituminous, brick, or concrete in Hamilton County, Ohio, with an estimated cost of $423,066.60 and Federal aid, $120,000.

SOME HIGH GRADE ROADS.

On a Massachusetts project, a short concrete road, the estimated cost is at the rate of $127,864 a mile. This is the highest average cost per mile so far shown in a Federal-aid road. A bituminous, brick or concrete road in Ohio will average $67,716 a mile and the 7.14 miles of concrete or brick in Pennsylvania mentioned will average $64,015. Another project in Pennsylvania will average $56,443 a mile.

In States in which the projects are all for brick, concrete, asphalt, or bituminous roads the average estimated cost is: Pennsylvania, $47,885; Maryland, $45,288.75; Ohio, $35,992; and Oklahoma, $26,779.

In the agreements executed Kansas leads in the estimated cost of roads and also in the amount of Federal-aid allowed. Two agreements in that State signed in July were for 29.578 miles of road, estimated to cost $1,302,451.12, with an allowance of $443,700 Federal aid. For a single project in Pennsylvania for which an agreement was signed and a modification of an agreement previously signed the estimated cost is $491,998.72 and the Federal aid $208,121.35. No other State received as much as $200,000 of Federal aid, though both New Jersey and Virginia approached that amount. The former received $192,175.92 for 3 projects estimated to cost $458,148.28, and the latter $190,847.22 for 4 projects to cost $334,102.64.

AUGUST APPROVALS AND AGREEMENTS.

In August 112 Federal-aid projects approved were for 1,246.92 miles of road, estimated to cost $18,238,303.19, for which the Federal-aid allowance is $7,171,784.84.

There were 81 agreements executed during the month and modifications of 20 previously executed. The mileage amounted to 697.59, the estimated cost was $12,159,034.77 and the amount of Federal aid allowed $5,190,791.15.

In the record of approvals for the month, Arkansas occupies first place in the estimated cost and mileage of projects and in the largest project. Minnesota is first in the total number of projects approved (11), and second in the amount of Federal-aid allowance. Pennsylvania received the largest amount of Federal aid and her six approved projects come second in the estimated cost of the roads.

BIG ARKANSAS PROJECT.

Arkansas had four projects approved, whose estimated cost is $3,166,338.93, and Federal aid requested of $475,000. Project No. 24, that State, is for 152.99 miles of asphalt and macadam road running from Grady to the Louisiana State line through Ashley, Desha, Drew, Chicot, and Lincoln Counties. It is estimated to cost $2,684,177.10, and a Federal-aid allowance of $332,000 is made for it. It is a part of the Arkansas-Louisiana highway.

Two other approvals in August were for projects whose estimated cost is in excess of $1,000,000. Project No. 9, Indiana is, for 40 miles of concrete, brick, or asphalt road in Johnson and Bartholomew Counties, estimated to cost $1,353,330, or $33,830 a mile. The Federal-aid allowance is $676,000, the largest made to a single project during the month. Project No. 30, Kansas, is estimated to cost $1,131,539.20, and calls for $306,750 Federal aid. It is for 20.45 miles of brick or concrete road in Lyon County, Kans. The cost per mile is $55,330.

In addition to Arkansas, project approvals for four States amounted to over $1,000,000. The estimated cost of the 33.41 miles of Pennsylvania projects approved is $1,786,103, an average cost of $53,430 a mile. The Federal-aid allowance is $702,782. Indiana's cost is next, for the single project already mentioned. The 11 projects in Minnesota aggregate 77.86 miles, are estimated to cost $1,188,080.86, and will receive a Federal-aid allowance of $604,536.76. Kansas follows with the estimated cost of $1,131,539.30 for her one approved project.

In the estimated cost of roads and the amount of Federal aid allotted for the projects executed by the Secretary of Agriculture during August Pennsylvania leads. Ten projects with an aggregate length of 53.98 miles are estimated to cost $2,477,483.78 and will receive $1,101,339.84 in Federal aid.

Fourteen Ohio projects aggregate 55.227 miles, have an estimated cost of $2,051,799.80 and a Federal-aid allowance of $704,650.

The estimated cost of the 85.06 miles of agreements for California projects is $1,372,644.56 and the Federal-aid allowance is $686,322.27.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR JULY, 1919.

State.	Project No.	County.	Length in miles	Type of construction.	Project statement approved.	Project agreement executed	Estimated cost.	Federal aid.
Alabama	12	Lowndes	[1] 2.51		July 22		[1] $15,737.12	[1] $7,868.56
	44	Dale	.625	Concrete		July 23	67,845.25	32,982.12
	45	do	7.90	Sand-clay		July 19	45,750.54	22,875.27
	58	Jefferson	3.15	Earth	July 7		19,882.50	9,941.25
	59	do	5.00	Concrete	do		173,415.00	86,707.50
	60	Monroe	9.26	Gravel	July 22		21,127.49	10,563.74
	61	Crenshaw	11.113	Sand-clay	do		31,977.27	15,988.63
Arizona	9	Pima	3.79	Concrete or bituminous	do		122,445.48	61,222.74
	10	Maricopa		Bridge	July 29		40,000.00	20,000.00
	14	Cochise	23.32	Earth	July 28		173,958.40	86,979.20
Arkansas	1	Carroll		Gravel		July 14	[2] 16,991.38	[2] 8,495.86
	17	Craighead	5.81	Macadam		July 2	69,509.55	10,000.00
	18	Benton		Gravel		July 14	[2] 17,736.28	[2] 8,868.14
	23	Jackson	8.85	do	July 10		86,416.88	40,000.00
	25	Jefferson	9.47	Bituminous	July 31		40,331.50	20,000.00
Colorado	12	Weld	.89	Concrete or bituminous		July 22	20,973.96	10,486.98
	13	Boulder	.417	Concrete	July 29		10,468.81	5,234.40
	14	do	.504	do	July 25		20,780.73	10,390.36
	16	Morgan	.45	Concrete or bituminous		July 29	10,996.97	5,498.48
Florida	16	De Soto	.67	Concrete		July 26	11,798.80	5,899.40
Georgia	1	Clayton, Henry, Pike, Spaulding, Monroe.		Sand-clay or top soil		July 11	[2] 158,078.80	[2] 79,456.92
	8	Montgomery, Wheeler		Bridge		July 19	[2] 44,915.57	[2] 22,457.79
	18	Dooley		Sand-clay		July 11	[2] 3,329.75	[2] 3,734.45
	76	Wheeler	10.30	do	July 18		78,908.50	39,454.25
Idaho	10	Elmore	12.50	Gravel	July 29		95,502.85	47,901.42
	13	Canyon and Owyhee		Bridge	July 7		89,980.00	44,990.00
	14	Bonneville	6.00	Gravel	July 11		51,533.68	25,776.84
	15	Bannock	8.92	Macadam	July 15		75,000.00	37,500.00
	17	do	9.00	Gravel and macadam	July 21		69,999.25	33,999.62
Illinois	3	Will	[1] 19.00	Brick	July 2		[1] 592,592.50	[1] 325,538.10
Indiana	3	Marion, Johnson	[1] 6.26	Brick, concrete, or bituminous	July 18		[1] 221,970.00	[1] 14,500.00
	7	Marion	6.10	do	do		230,843.00	50,000.00
	8	Hamilton, Marion	[1] 4.76	do	do		[1] 171,150.00	[1] 15,750.00
	12	Jackson	8.80	do	July 22		343,380.00	171,690.00
Iowa	46	Pottawatomie	2.65	Earth	July 21		24,310.00	12,155.00
Kansas	15	Reno	17.57			July 1	729,496.74	263,580.00
	24	Sedgwick	12.008	Brick		July 11	592,954.37	180,120.00
Kentucky	2A	Fayette	6.383			June 30	[3] 200,000.00	[3] 100,000.00
Louisiana	15	Avoyelles		Gravel		July 2	[2] 1,660.97	[2] 5,348.82
	35	Jefferson Davis	7.50	Sand-clay or gravel		July 11	64,589.66	32,294.83
	39	Concordia	18.10	Gravel	July 29		200,226.40	100,113.20
	40	Tensas	3.03	do	July 21		23,777.05	11,888.52
	42	Jefferson	13.58	do	July 25		135,493.09	62,746.54
Maryland	6B	Prince Georges, Howard, Baltimore.		Concrete		July 28	[2] 2,475.00	[2] 1,327.49
	28	Anne Arundel	10.50	do	July 29		506,000.00	210,000.00
	33	Carroll	5.77	do	do		230,848.75	115,400.00
Massachusetts	9	Essex	3.122	Bituminous macadam		July 11	130,944.55	65,472.27
	14	Barnstable	3.345	Bituminous	July 29		52,037.15	26,018.57
	15	Plymouth	4.38	Concrete	do		121,328.90	60,664.45
	23	Berkshire	2.123	do	July 26		62,185.75	31,092.87
	24	Bristol	2.756	Bituminous	July 28		39,055.50	19,527.75
	25	Middlesex	.578	Concrete	do		73,906.79	36,359.08
Minnesota	17	Carlton	8.59	Gravel		July 1	34,666.64	17,333.32
	26	Todd	4.80	do		July 19	30,537.69	10,000.00
	35	Hennepin	5.86	Concrete, brick, or asphalt		July 9	247,900.00	60,000.00
	38	Mower	24.50	Earth	July 22		145,244.00	72,622.00
	41	Isanti	5.66	Gravel	do		48,481.12	24,240.56
	42	Washington	7.50	do	July 18		65,438.01	25,000.00
	43	Cottonwood	4.07	do	July 7		23,159.63	11,579.81
	44	Sherburne	4.43	Asphalt, brick. or concrete		July 11	136,180.36	67,430.55
	49	Chippewa	15.00	Gravel		July 31	83,066.37	41,533.18
	51	Crow Wing	19.93	do	July 25		108,909.62	54,454.81
	54	Lac qui Parle	38.50	do	July 7		72,111.29	36,055.64
	59	Becker	3.97	do		July 2	21,928.69	10,964.34
	60	Sherburne	6.50	Asphalt, brick, or concrete	July 31		229,141.00	114,570.50
Mississippi	3	Hinds	[4] 3.00		July 1		[4] 13,578.90	[4] 5,000.00
	4	Scott	[4] 5.50		do		[4] 11,165.00	[4] 5,000.00
	8	Perry	[4] 21.00		do		[4] 32,972.00	[4] 10,000.00
	16	Simpson	7.842	Clay-gravel		July 11	44,509.78	22,259.89
	29	Union	17.80	Slag or gravel	July 7		172,245.04	60,000.00
	32	Lee	16.20	Concrete	July 31		312,620.00	125,000.00
	43	George	7.30	Earth	July 10		15,400.00	7,500.00
Missouri	5	Scott	7.19	Gravel		July 1	59,287.55	14,821.89
	10	do	27.44	do		do	211,463.57	52,865.89
	17	Jasper	6.00	Concrete		do	135,684.89	67,842.44
Montana	1	Wibaux	4.74	Gravel		July 2	21,978.33	10,989.16
	20	Missoula	6.87	do		do	21,993.54	10,996.77
	30	Broadwater		Bridge		do	70,836.15	35,418.07
	45	Missoula	[4] 2.50	Macadam	[4] July 10		[4] 11,000.00	[4] 5,500.00
Nebraska	26	Chase and Hayes	15.97	Earth		July 1	51,623.09	25,811.54
	29	Butler		do		do	[2] 4,472.10	[2] 2,236.05
	37	Sherman	11.90	do	July 11		37,455.00	18,727.50
	38	Frontier	12.08	do		July 11	34,481.92	17,240.96
	41	Dundy	12.72	do		July 1	56,036.64	28,018.32
	42	Custer and Loup	18.20	Earth and sand-clay	July 11		52,140.00	26,070.00
	43	Johnson	17.00	Earth	July 6		25,850.00	12,925.00
	51	Franklin and Kearney	30.00	do	July 21		60,995.00	30,497.50
	52	Phelps	16.00	Sand-clay	July 10		45,315.60	22,657.80
	54	Deuel	12.00	Earth	July 15		25,421.00	12,710.50
	59	Wheeler	8.00	Sand-clay	July 11		42,398.40	21,199.20
	62	Thomas	4.80	Earth and sand-clay	July 7		22,330.00	11,165.00
	73	Buffalo	20.40	Earth		July 21	79,431.60	39,715.80
	76	Box Butte and Dawes	56.90	do	July 29		122,100.00	61,050.00
	94	Arthur and Keith	27.80	Sand-clay	July 15		134,349.60	67,174.80
	97	Pawnee	30.60	Earth	July 10		84,150.00	42,075.00
New Hampshire	20	Merrimack and Grafton	1.38	Gravel		July 11	20,487.89	10,243.94
	23	Hillsborough	2.06	do		July 1	29,958.06	14,979.03
	25	Merrimack	1.10	do		July 11	7,864.12	3,932.06
	37	Rockingham	9.666	Bituminous		July 1	195,109.13	97,554.56

[1] Revised statement. Figures given are increases over those in the original statement approved.

[2] Modified agreement. Figures given are increases over those in the original agreement signed.

[3] Should have been included in the June record

[4] Withdnawn.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR JULY, 1919—Continued.

State.	Project No.	County.	Length in miles	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid.
New Hampshire	47	Merrimack and Sullivan	1.33	Gravel	July 27		$17,223.25	$8,611.62
	48	Cheshire	.87	do	July 15		19,152.21	9,576.10
	52	Sullivan and Merrimack	1.27	do	July 26		15,044.15	7,522.07
	56	Cheshire	.945	do	July 21		11,478.83	5,739.41
	58	Grafton	1.51	do	July 15		29,920.00	14,960.00
	64	Rockingham	.77	do	July 18		10,998.08	5,499.04
	65	Hillsborough	1.23	do	July 26		13,111.56	6,555.78
	68	do	1.27	do	July 21		15,128.19	7,564.09
	69	Cheshire and Sullivan	.62	do	July 26		9,775.76	4,887.88
New Jersey	3	Somerset and Middlesex	3.84	Concrete		July 1	207,053.90	76,800.00
	4	Monmouth	1.59	do		do	87,254.64	33,456.05
	11	Atlantic	4.418	do		July 19	163,839.74	81,919.87
	12	do	9.87	do	July 15		385,378.31	192,689.15
	13	Gloucester and Salem	7.238	do	do		317,635.21	144,760.00
New Mexico	15	Dona Ana	11.68	do		July 11	229,246.84	114,623.42
	21	Taos	8.00	Gravel	July 1		96,000.00	48,000.00
North Carolina	16	Haywood		Gravel and sand-clay		July 1		[1] 15,000.00
	25	Person	8.175	Sand-clay	July 31		76,440.43	38,220.21
	28	Lee	[2] 12.05	Gravel	[2] July 17		[2] 27,933.95	[2] 10,000.00
	40	Union	4.287	Sand-clay or gravel		July 9	10,679.51	4,000.00
	41	Watauga	11.60	Gravel	July 7		61,652.41	25,000.00
	46	Beaufort	.73	Concrete	do		24,178.70	12,089.35
	47	Guilford	4.626	Concrete or asphalt	July 31		144,036.86	72,018.43
	48	Northampton	8.60	Sand-clay	July 21		45,815.00	22,907.50
	49	Lenoir	6.017	Asphalt or concrete	July 15		190,833.50	95,416.75
	51	Guilford	2.26	do	July 26		59,118.40	29,559.20
	52	Cabarrus	8.986	Sand-clay or gravel	July 21		96,857.75	48,428.87
	55	Mecklenburg	10.71	Bituminous	July 29		241,943.76	120,991.88
North Dakota	44	Bottineau	4.50	Earth	July 15		20,000.00	10,000.00
	45	Foster	11.10	do	July 21		19,800.00	9,900.00
	51	Grand Fork	1.087	Concrete	July 26		39,605.50	19,802.75
Ohio	40	Medina	4.73	Bituminous or concrete		July 1	153,000.00	75,000.00
	53	Mercer	5.74	Concrete	July 28		166,000.00	61,500.00
	54	do	1.68	do	July 22		51,000.00	16,000.00
	63	Hamilton	2.75	Bituminous, brick, or concrete	July 29		186,221.20	55,000.00
	64	do	6.00	do	July 28		423,066.60	120,000.00
	71	Darke	4.60	Concrete	July 11		162,000.00	45,000.00
	72	do	4.50	do	July 10		141,000.00	45,000.00
	73	do	4.31	do	do		137,000.00	45,000.00
	82	Cuyahoga	2.73	Brick or bituminous	July 11		144,949.00	54,600.00
	83	do	9.76	Bituminous	July 31		163,370.72	81,000.00
	91	Wood	6.74	do	July 11		165,083.60	37,700.00
	92	Crawford	2.36	Brick or bituminous	do		106,000.00	25,000.00
	95	Paulding	3.00	Brick or concrete	July 31		114,000.00	30,000.00
Oklahoma	7	Muskogee	2.50	Bituminous		July 21	84,189.60	42,094.80
	12	Tulsa	46.158	Concrete or bituminous	July 11		1,271,555.64	600,000.00
	15	Washington	20.00	Concrete	July 7		500,000.00	250,000.00
Oregon	9	Baker	4.65	Gravel		July 11	51,224.54	22,612.27
	20	Wasco	11.50	Asphalt or concrete	July 11		285,000.00	117,500.00
Pennsylvania	7	Lawrence		Reinforced concrete		July 2	[1] 54,048.77	[1] 49,800.00
	34	Berks and Schuylkill	7.59	Concrete		July 19	437,949.95	158,321.35
	45	Center	5.29	Concrete or bituminous	July 7		251,425.74	105,800.00
	46	Lancaster	7.137	do	do		292,931.10	142,740.00
	47	Lycoming	7.44	Concrete	July 10		361,452.30	148,800.00
	48	Potter	5.00	Concrete or bituminous	July 7		245,789.15	100,000.00
	49	Dauphin	4.69	Concrete	July 16		197,110.10	93,800.00
	50	Lancaster	4.07	Concrete or bituminous	July 15		193,237.00	81,400.00
	51	McKean	5.96	Concrete or brick	July 16		296,181.60	119,200.00
	52	Northumberland	4.81	Brick, concrete, or bituminous	do		193,247.22	96,200.00
	54	Bucks	2.82	Bituminous or concrete	July 29		110,207.90	55,103.95
	57	Clearfield	2.46	Concrete or brick	do		111,782.00	49,200.00
	59	Lehigh	5.70	do	do		265,482.80	114,000.00
	60	Somerset	7.14	do	do		457,066.50	147,071.00
	61	do	6.06	do	July 31		295,755.90	124,466.45
	62	Sullivan	3.29	Asphalt, brick, or concrete	do		185,697.60	65,800.00
	63	Susquehanna	5.73	Concrete	do		265,433.30	114,600.00
	64	Tioga	5.31	Asphalt, brick, or concrete	do		276,995.40	106,200.00
	66	Lackawanna and Wyoming	13.24	Bituminous or concrete	July 29		609,232.80	304,616.00
South Carolina	7	Horry	20.37	Sand-clay		July 19	63,827.58	31,913.79
	24	Spartanburg	1.83	Asphalt		do	53,146.42	26,573.21
	25	Lexington	23.97	Sand-clay	July 29		67,693.58	20,422.10
	33	Beaufort		Bridge piers	do		13,192.30	6,596.15
South Dakota	10	Clark	16.45	Gravel		July 29	95,136.52	47,586.26
Texas	18	Franklin	12.47	Gravel		July 2	58,920.00	25,000.00
	52	Callahan	22.75	do	July 28		[3] 180,065.72	[3] 49,773.15
	84	Van Zandt	9.889	do	July 11		88,240.22	40,000.00
	85	Freestone	10.30	Gravel or macadam	July 21		154,213.41	37,500.00
	86	Montague	18.00	Gravel	July 29		202,276.93	100,998.87
	91	Taylor	2.998	do	do		13,618.48	4,950.00
	92	Hood	30.00	Gravel and macadam	July 11		208,397.86	70,000.00
	94	Baylor	4.313	Sand-clay	July 29		21,400.15	10,692.22
	95	Red River	2.25	Concrete and gravel	July 21		30,000.00	15,000.00
Utah	27	Cache	10.45	Concrete	July 15		291,280.25	145,640.00
Vermont	11	Chittenden	1.40	Concrete or bituminous	July 7		53,460.00	26,730.00
Virginia	7	Albemarle		Macadam		July 2	[1] 8,262.69	[1] 4,131.34
	9	Chesterfield		Concrete		July 11		[1] 3,908.69
	10	James City and York		do		do		[1] 9,887.22
	29	Princess Anne	2.775	do		July 14	84,360.60	42,180.30
	31	Northampton	1.59	do	July 11		45,991.00	22,995.50
	34	Norfolk	4.59	do		July 1	132,950.40	66,475.20
	36	Halifax	3.42	do		July 11	92,502.85	46,251.42
	39	Buckingham	6.18	Sand-clay	July 29		49,417.50	24,708.75
	41	Alleghany	9.50	Macadam and bituminous	July 15		164,609.50	82,304.75
	42	King George	5.70	Sand-clay		July 12	36,026.10	18,013.05
	46	Rappahannock	7.40	Macadam	July 29		133,210.00	66,605.00
	58	Prince George	11.00	Gravel	July 7		72,820.00	36,410.00
Washington	33	Clarke	4.25	Concrete	July 18		120,899.35	60,494.67
	35	Whitman	21.95	Macadam	do		253,922.51	126,961.25
	36	Clarke	3.32	Concrete	July 18		79,085.05	39,542.52
	37	Douglas	2.79	Macadam	do		25,399.00	12,699.50

[1] Modified agreement. Figures given are increases over those of original agreement.
[2] Withdrawn.
[3] Revised statement. Figures given are increases over the amounts in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR JULY, 1919—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement executed.	Estimated cost.	Federal aid.
Washington	38	Yakima	2.95	Concrete	July 29		$115,123.25	$57,561.62
	39	do	5.31	do	do		170,045.70	85,022.85
	40	Walla Walla	3.788	do	do		139,901.25	69,950.62
	41	Thurston	6.27	Gravel	July 22		108,591.52	54,295.76
	42	Grays Harbor	4.20	Concrete	July 29		119,907.43	59,953.71
	43	do	2.87	do	July 22		82,558.30	41,279.15
West Virginia	31	Lewis	1.25	Brick		July 11	56,500.00	25,000.00
	37	Marion	[1] .76	Concrete	[1] July 11		[1] 32,979.92	[1] 15,200.00
	48	Boone	5.00	Earth		July 18	66,000.00	33,000.00
	49	Marion	1.10	Brick	July 18		50,796.00	25,165.00
	50	Clay	4.50	Earth	July 25		47,170.00	23,575.00
	51	Wayne	3.20	do	do		66,000.00	30,000.00
	52	Hancock	2.00	Brick	July 7		53,250.00	18,300.00
	53	Harrison	2.50	do	July 15		88,265.50	38,000.00
	54	Greenbrier	2.00	Bituminous	do		30,973.80	15,486.90
Wisconsin	22	Polk	13.127	Graded and drained earth		July 21	53,983.04	17,994.34
	28	La Crosse	3.31	Bituminous macadam		July 11	41,771.67	13,923.89
	31	Taylor	10.56	Earth		July 31	34,077.96	11,359.32
	38	Marathon		Gravel		July 2	[2] 8,649.78	[2] 2,883.26
	40	Sheboygan		Bituminous macadam		July 19	[2] 4,045.42	[2] 1,348.47
	55	Door and Kewanie	8.69	Gravel		[3] June 30	[3] 50,950.27	[3] 16,850.09
	67	Monroe	2.82	Earth	July 31		30,446.68	10,148.89
	80	Green	5.407	do		July 15	38,996.94	12,998.98
	87	Buffalo	[2] .70	do	July 22		[4] 20,601.46	[4] 6,903.82
	90	Washburn	4.492	do		July 21	25,998.73	8,666.24
	91	Rusk	6.02	do		July 16	24,018.98	8,006.33
	93	Marquette	4.06	Sand-clay	July 21		25,386.35	8,462.11
	94	Marathon	4.35	Concrete	July 7		103,170.90	34,390.30
	97	Sauk	2.34	Gravel	July 28		50.292.00	16,764.66
	98	Washburn	.57	Earth	July 18		5,995.00	1,998.33
Wyoming	33	Albany	2.10	Macadam	July 8		25,575.00	12,787,50
Total	226		1,636.305				26,849,264.51	9,814,599.31

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[1] Statements heretofore approved withdrawn.
[2] Modified agreement. Figures given are increases over those in the original agreement.
[3] Should have been included in the June record.
[4] Revised statement. Figures given are increases over those in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN AUGUST, 1919.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	26	Cleburne		Gravel		Aug. 29	[1] $15,933.65	[1] $7,766.82
	42	Talladega	5.7	Sand-clay	Aug. 8		42,056.74	21,028.37
	53	Calhoun	3.2	do	Aug. 19		16,412.00	8,206.00
	63	Dale	6.5	do	Aug. 7		36,795.00	18,397.50
	64	Pike	13.96	Gravel	Aug. 22		103,625.50	51,812.75
	65	do	8.83	Sand-clay and gravel	Aug. 16		50,336.00	25,168.00
Arizona	11	Cochise	8.463	Concrete	Aug. 5		232,799.83	116,399.91
	12	Yavapai	1.961	Macadam	Aug. 7		121,969.17	39,220.00
	13	Greenlee	5.276	Gravel	Aug. 16		171,900.85	85,950.47
	17	Yavapai	5.0	Macadam	Aug. 7		166,761.98	83,380.99
Arkansas	24	Ashley, Desha, Drew, Chicot, Lincoln.	152.99	Asphalt and macadam	Aug. 1		2,684,177.10	332,000.00
	26	Jackson	14.26	Bituminous	Aug. 14		134,184.31	60,000.00
	28	St. Francis	18.19	Gravel	Aug. 12		268,262.72	50,000.00
	29	Craighead	5.62	Macadam	Aug. 14		79,714.80	33,000.00
California	11	Fresno	8.17	Concrete		Aug. 29	246,668.29	123,334.14
	12	Merced	14.89	do		Aug. 1	266,667.85	133,333.92
	13	Los Angeles	17.62	do		Aug. 29	310,338.10	155,194.05
	14A	Mendocino	24.12	Earth		Aug. 1	152,946.92	76,473.46
	16	Humboldt	2.80	do		Aug. 1	39,471.56	19,735.78
	17	Del Norte	7.73	do		Aug. 11	239,133.84	119,566.92
	19	Mendocino	9.73	do		Aug. 29	117,368.84	58,684.00
	21	Ventura	5.19	Concrete	Aug. 7		167,255.00	83,627.50
	22	Los Angeles	1.29	do	do		42,240.00	21,120.00
	23	do	5.23	Bituminous	Aug. 12		94,624.75	47,312.37
	24	Orange	9.37	do	Aug. 9		145,225.85	72,612.92
	25	Santa Barbara	3.56	Concrete	Aug. 16		85,382.00	42,691.00
	26	Kern	10.7	do	Aug. 11		324,170.00	162,085.00
Colorado	10	Adams	1.786	Concrete or bituminous		Aug. 27	42,793.96	21,396.98
	21	Otero	.4	Concrete	Aug. 5		10,654.87	5,327.43
	22	do	.407	do	Aug. 7		10,572.92	5,286.46
	24	Castilla	6.6	Earth and gravel	Aug. 9		20,363.85	10,181.92
	57	Prowers	1.408	Concrete	Aug. 8		39,508.70	19,754.35
	60	Otero	.413	do	Aug. 7		10,618.85	5,309.47
	61	do	.4	do	do		10,602.07	5,301.03
	62	do	.909	do	Aug. 16		23,097.80	11,548.90
	63	do	.918	do	do		23,431.65	11,715.82
Connecticut	5	Fairfield	11.18	Bituminous		Aug. 1	314,060.89	157,030.44
Delaware	1B	New Castle	.492	Brick		Aug. 26	50,734.64	4,500.00
	3	Kent, Sussex	4.006	Concrete		do	175,395.55	36,000.00
Florida	15	De Soto	3.26	do		Aug. 11	54,570.67	20,000.00
Georgia	77	Charlton	19.2	Bituminous	Aug. 11		285,441.86	142,720.93
	78	Pulaski		Bridge and approaches	Aug. 16		180,932.40	90,466.20
Idaho	12	Elmore	7.4	Macadam	Aug. 14		74,955.54	37,477.77
Illinois	[2] 1	Du Page, Kane, DeKalb, Ogle, Lee, Whiteside.	11.146	Concrete and bituminous macadam resurfacing.		Aug. 4	306,789.63	153,394.81
	[2] 1	do	4.851	do		do	152,968.91	76,484.47
	[2] 1	do		do		do	[2] 23,632.72	[2] 20,990.67
	[2] 1	do	6.502	do		do	205,336.71	102,668.35
	2	Kankakee, Iroquois		Bituminous macadam and concrete		do	[1] 2,554.17	[1] 1,277.09

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[1] Modified agreements. Amounts given are increases over those in the original.
[2] Separate agreements for portions of project No. 1. The first is for sections 1, 5, 8, and 18, the second for section 4; the third for section 7; and the fourth for section 15. That for section 7 is a modification of the original, and the amounts given are increases over those in the original agreement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN AUGUST, 1919—Continued.

State	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Indiana	9	Bartholomew, Johnson	40.00	Concrete, brick, or asphalt	Aug. 27		$1,353,330.00	$676,665.00
Iowa	12	Dallas	16.8	Gravel		Aug. 4	37,288.07	18,000.00
	27	Appanoose	10.58	Graded earth		Aug. 26	50,649.01	25,000.00
	28	Sioux	24.4	Earth		do.	77,782.10	29,381.20
	34	Keokuk	12.21	do.		Aug. 1	58,366.79	29,000.00
Kansas	10	Geary	7.471	Concrete		Aug. 27	270,809.81	112,065.00
	25B	Wyandotte	1.274	Brick or concrete		Aug. 26	52,512.07	19,110.00
	30	Lyon	20.45	do.	Aug. 16		1,131,539.20	306,750.00
Louisiana	19	St. Landry	11.3	Gravel	Aug. 5		130,537.33	50,000.00
	21	West Baton Rouge		do.		Aug. 11	[1] 17,263.54	[1] 13,128.94
	32	Grant	20.23	do.		Aug. 12	214,629.58	107,314.79
	36	Tangipahoa	12.56	do.	Aug. 27		110,777.75	55,388.87
	38	Natchitoches	17.89	do.	Aug. 16		213,756.51	101,878.25
	43	Calcasieu	11.71	Shell and gravel	Aug. 27		245,092.59	122,546.29
	45	Caddo	8.35	Gravel	do.		65,945.27	32,972.63
Maryland	6A	Prince Georges, Howard, Baltimore.		Concrete		Aug. 22		[1] 18,524.98
	14	Frederick, Washington	3.5	do.		Aug. 7	99,849.97	49,924.98
	16	Howard	2.51	do.		Aug. 29	97,838.95	48,919.47
	17A	Harford	2.6	do.		Aug. 1	70,781.28	35,490.64
	18	Cecil	2.088	do.		Aug. 29	69,966.88	34,983.44
	20	Dorchester	2.15	do.		do.	65,976.60	32,988.30
Massachusetts	10	Norfolk	2.42	Bituminous		Aug. 11	81,374.75	40,687.37
	12	Essex	2.173	do.		Aug. 16	43,703.00	21,851.50
	18	Worcester	2.797	Concrete	Aug. 11		124,533.75	55,940.00
	19	Bristol	2.116	do.		Aug. 7	86,898.90	42,320.00
	20	Middlesex	2.173	Bituminous		Aug. 11	43,703.00	21,851.50
Michigan	20	Van Buren, Kalamazoo		Concrete		Aug. 29	[1] 54,275.43	[1] 36,863.75
	24	Berrien		Macadam surface treated		Aug. 21	[1] 38,975.27	[1] 15,058.22
Minnesota	1	Pine		Gravel		Aug. 4	[1] 37,568.55	[1] 24,859.34
	20	Goodhue		do.		do.	[1] 12,519.38	[1] 38,002.86
	23	Dakota	6.0	Concrete, brick, or asphalt		Aug. 12	205,031.21	100,000.00
	24	Morrison	[2] 40.85	Gravel	Aug. 11		[2] 75,196.00	[2] 23,798.00
	36	Faribault	26.1	do.	Aug. 27		162,699.68	81,349.84
	39	Fillmore	8.48	do.	do.		66,607.30	30,000.00
	40	Meeker	16.35	do.	Aug. 7		115,867.40	57,933.70
	47	Pope	16.20	do.		Aug. 21	73,076.32	36,538.16
	52	Itasca	9.5	do.	Aug. 7		60,106.91	30,053.45
	53	Lyon	9.0	do.	Aug. 9		103,938.84	51,991.92
	55	Lac qui Parle	6.5	do.	Aug. 7		9,605.48	4,802.74
	56	do.	16.8	do.	Aug. 9		33,289.73	16,644.86
	58	Noble	5.5	Concrete, brick, or asphalt		Aug. 1	145,617.34	60,000.00
	63	Stevens	9.18	do.	Aug. 21		267,346.86	133,673.43
	64	Rice	12.8	do.	Aug. 16		420,444.49	210,222.24
	67	Pennington	3.7	Gravel	Aug. 27		23,325.17	11,662.58
Mississippi	18	Rankin	3.775	do.		Aug. 4	20,774.59	10,387.29
	30	Lauderdale	6.727	do.		do.	40,259.18	20,000.00
	40	Monroe	14.00	do.	Aug. 12		49,995.00	20,000.00
	65	Yazoo	6.9	do.	do.		51,425.00	25,712.50
Montana	46	Jefferson	3.5	Earth	Aug. 27		22,000.00	11,000.00
	49	Meagher	23.00	do.	do.		45,980.00	22,990.00
	51	Gallatin	.75	Concrete	Aug. 15		49,500.00	15,000.00
Nebraska	40	Thayer	7.25	Gravel	Aug. 16		23,496.00	11,748.00
	49	Burt, Dakota, Thurston	48.5	Earth	Aug. 22		107,800.00	53,900.00
	56	Seward, York, Hamilton	18.987	do.		Aug. 6	167,871.24	83,935.62
	57	Dixon	11.00	Sand-clay	Aug. 14		34,056.00	17,028.00
	64	Pierce	12.65	Earth	Aug. 22		28,820.00	14,410.00
	71	Franklin, Harlan	27.05	do.	Aug. 18		71,500.00	35,750.00
	74	Dundy	17.5	do.	Aug. 11		41,250.00	20,625.00
	79	Morrill	34.2	Earth and sand-clay	Aug. 14		76,560.00	38,280.00
	87	Madison, Stanton	9.9	Earth	Aug. 15		38,500.00	19,250.00
	95	Chase	24.3	Sand-clay	Aug. 16		47,410.00	23,705.00
	100	Douglas	9.9	Earth	Aug. 11		38,500.00	19,250.00
New Hampshire	45	Strafford	1.25	Gravel	Aug. 20		9,900.00	4,950.00
	46	Rockingham	1.00	Macadam	Aug. 12		13,165.02	6,582.51
	54	Strafford	2.045	Gravel	Aug. 11		20,784.17	10,392.08
	61	Cheshire	2.49	do.	Aug. 27		21,903.20	10,951.60
	63	Rockingham	.81	do.	Aug. 12		7,474.66	3,737.33
	66	Carroll	1.21	do.	Aug. 11		10,185.91	5,092.95
	67	Strafford	.80	do.	Aug. 12		6,507.49	3,253.74
	70	Coos	.568	Macadam	Aug. 15		11,863.17	5,931.58
	73	Carroll	.84	Gravel	Aug. 12		14,816.37	7,408.18
	75	Belknap	1.59	do.	Aug. 11		13,233.13	6,616.56
New Jersey	2	Mercer	5.99	Concrete		Aug. 1	377,270.73	119,800.00
	10	Hunterdon	2.03	do.	Aug. 14		165,625.99	50,142.50
	14	Somerset, Middlesex	3.665	do.	Aug. 5		266,055.91	73,300.00
	16	Hunterdon	2.13	do.	Aug. 14		256,319.51	42,600.00
New Mexico	22	Guadalupe	18.00	Gravel	do.		117,447.00	58,723.50
	23	De Baca	10.00	do.	do.		87,972.50	43,986.25
	29	Eddy	21.00	Earth	Aug. 12		89,487.20	44,743.60
North Carolina	13	Wayne	12.6	Sand-clay or gravel	Aug. 11		51,535.00	25,767.50
	18	Alexander	9.8	Topsoil		Aug. 4	66,446.49	25,000.00
	27	Orange	17.17	Topsoil or sand-clay		Aug. 19	34,132.07	12,000.00
	42	Stanley	11.67	Sand-clay or gravel		Aug. 12	80,922.15	16,700.00
	50	Guilford	2.003	Bituminous	Aug. 11		56,622.28	28,311.14
	54	Wake	6.9	do.	Aug. 12		246,336.64	123,168.32
North Dakota	7	Stutsman		Earth		Aug. 20	[1] 4,949.94	[1] 2,474.97
	11	Cavalier		Graded earth		Aug. 29	[1] 1,090.86	[1] 545.43
	18	Ramsey	4.51	Earth		do.	12,384.50	6,192.25
	40	Bottineau	8.01	Earth and gravel		do.	24,769.11	12,384.55
	43	do.	10.13	Gravel		do.	42,960.76	21,480.38
	46	Traill	4.02	Earth	Aug. 27		6,400.00	3,200.00
Ohio	11	Ashtabula		Brick or concrete		Aug. 12	63,000.00	31,500.00
	24A	Madison	2.47	Concrete, asphalt, or brick		do.	52,200.00	24,700.00
	24B	do.	5.92	do.		do.	165,000.00	59,200.00
	30	Delaware	6.18	Concrete or macadam		Aug. 19	201,000.00	62,000.00
	36	Columbiana	2.961	Concrete		Aug. 26	88,000.00	35,600.00
	43	Ottawa	7.15	do.		Aug. 16	244,500.00	71,500.00
	47	Wood	6.13	Concrete or asphalt		Aug. 26	200,000.00	90,000.00
	50	Columbiana, Mahoning	4.12	Brick		Aug. 20	150,000.00	54,000.00

[1] Modified agreements. Amounts given are increases over those in the originals.

[2] Revised statement. Figures given are decreases in estimated cost and Federal aid in original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN AUGUST, 1919—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Ohio	51	Sandusky	5.76	Brick or bituminous		Aug. 4	$345,000.00	$86,400.00
	52	Huron	1.28	Brick		Aug. 12	51,000.00	17,000.00
	65	Hancock	6.04	Brick, asphalt, or concrete		Aug. 16	241,600.00	90,000.00
	66	Defiance	2.04	Concrete		Aug. 26	55,500.00	22,750.00
	78	Mahoning, Columbiana	2.15	Brick		do	94,999.80	15,000.00
	80	Washington	3.026	Concrete		Aug. 4	100,000.00	50,000.00
	86	Paulding	2.02	do	Aug. 11		61,500.00	20,200.00
	93	Gallia	6.00	Bituminous	Aug. 27		130,000.00	65,000.00
	94	Lawrence	4.39	do	do		120,000.00	60,000.00
	96	Paulding	2.02	Concrete	Aug. 11		61,800.00	20,200.00
	99	Jefferson	2.27	do	Aug. 27		106,843.00	45,000.00
	100	Harrison	3.76	do	do		138,600.00	50,000.00
Oklahoma	13	Pushmataha		Bridge	Aug. 14		150,000.00	75,000.00
	16	Hughes		do	Aug. 15		12,156.92	6,078.46
Oregon	18	Polk	13.07	Hard surface		Aug. 26	447,667.22	223,833.61
	21	Clatsop	14.8	Bituminous	Aug. 12		318,835.00	159,417.50
	22	do		Bridge	Aug. 14		255,860.00	85,286.66
Pennsylvania	8	Erie	5.19	Cement concrete or bituminous concrete on concrete base.		Aug. 26	261,452.87	122,757.73
	35	Tioga	4.98	Concrete		Aug. 12	239,319.09	99,600.00
	36	Blair	2.58	do		do	112,771.78	51,600.00
	37	Butler	6.10	Concrete or bituminous		Aug. 16	254,067.00	122,000.00
	40	McKean	10.11	Concrete		Aug. 26	488,304.34	207,489.78
	41	Mercer	3.39	Concrete or bituminous		Aug. 12	130,424.67	65,212.33
	43	Wayne	5.244	do		Aug. 28	231,331.65	104,880.00
	44	Cambria	6.1	Concrete		Aug. 26	285,948.85	122,000.00
	45	Center	5.29	Concrete or bituminous		Aug. 27	237,270.55	105,800.00
	48	Potter	5.00	do		Aug. 29	236,552.98	100,000.00
	53	Bradford	5.94	Bituminous, brick, or concrete	Aug. 11		329,322.40	118,800.00
	55	Butler	7.89	Brick or concrete	do		390,920.20	157,800.00
	56	Center	2.33	Bituminous or concrete	Aug. 9		108,351.10	46,600.00
	58	Fayette	4.98	Brick or concrete	Aug. 27		302,128.20	99,600.00
	65	Westmoreland	6.07	do	Aug. 11		326,691.20	134,659.00
	67	York	6.2	do	Aug. 7		328,689.90	145,323.00
Rhode Island	5	Providence, Kent	.945	Bituminous	Aug. 11		27,178.14	13,589.07
South Carolina	11	Chester	9.46	Sand-clay		Aug. 12	76,923.11	38,461.55
South Dakota	6	Moody	13.56	Earth, graveled in part		Aug. 4	62,574.57	31,287.28
	7	Deuel		Gravel		do	[1] 4,238.23	[1] 2,119.12
	8	Butte		Earth		do	[1] 5,888.45	[1] 2,944.22
	9	Brown	12.84	Gravel		Aug. 9	94,954.00	47,477.00
	12	Minnehaha	21.82	do		Aug. 21	167,213.23	83,606.61
Tennessee	11	Johnson, Sullivan	21.92	Earth and macadam	Aug. 5		168,387.45	70,000.00
	12	Claiborne, Union	13.714	Macadam	do		221,057.69	110,528.84
Texas	28	Morris		Sand-clay		Aug. 4	13,626.00	6,813.39
	33	Harris	[2] —.497	Gravel, shell base, bituminous surface		Aug. 29	[2] —2,753.80	[2] —120.03
	36	Caldwell	[2] —2.31	Gravel		Aug. 4	[2] —2,267.33	
	39	Dallas	9.125	Concrete		do	380,916.00	78,000.00
	40	Bell	36.65	Bituminous gravel		Aug. 9	145,200.89	50,000.00
	70	Colorado	17.12	do		Aug. 4	161,986.79	44,000.00
	76	Galveston		Shell		do	[1] 5,108.32	[1] 3,500.00
	79	Caldwell	6.67	Gravel	Aug. 14		11,785.72	5,892.86
	81	Freestone	2.79	Gravel or macadam		Aug. 4	44,273.58	20,000.00
	87	Travis	10.00	Bituminous	Aug. 14		32,853.20	16,426.50
	96	Fisher	9.00	Gravel	Aug. 8		64,068.40	32,034.00
	98	Collins	25.00	Shale	Aug. 27		328,786.24	172,926.86
Utah	19	Garfield, Piute	51.10	Macadam	Aug. 7		328,581.00	164,290.50
	25	Juab, Utah	23.6	Concrete	Aug. 27		606,260.53	303,130.26
Virginia	21	Frederick	5.37	Macadam		Aug. 29	88,333.10	44,166.55
	35	Rockbridge	4.27	do		do	64,535.90	32,267.95
	47	Hanover, Louisa	21.50	Sand-clay	Aug. 14		101,653.75	50,826.87
	48A	Amherst, Bedford	5.473	Macadam		Aug. 29	109,714.44	54,857.22
	50	Campbell	2.11	do		do	46,056.12	23,028.06
	51	Loudoun	4.5	do	Aug. 5		73,755.00	36,877.50
	52	Lee	5.25	do	Aug. 9		83,050.00	41,525.00
	53	Fauquier	3.1	do	do		42,680.00	21,340.00
	62	Roanoke	.718	Concrete	Aug. 12		22,550.00	11,275.00
	63	Warren	1.65	Bituminous	Aug. 11		26,455.00	13,227.50
West Virginia	3A	Pendleton	10.0	Graded and drained earth		Aug. 27	25,709.31	12,500.00
	16	Barbour		Bituminous macadam		Aug. 1	[1] 16,082.00	[1] 8,000.00
	27	do		Macadam		Aug. 21	[1] 2,740.50	[1] 1,890.00
	39	Doddridge	2.82	Concrete		Aug. 1	64,780.00	29,780.00
	40	Wood	2.00	do		Aug. 4	36,000.00	18,000.00
	46	Ohio	1.06	do		Aug. 21	37,965.00	18,000.00
	55	Tyler	1.00	Bituminous	Aug. 9		29,667.40	14,833.70
	56	Jackson	.35	Concrete	Aug. 12		13,000.00	6,500.00
	57	Cabell	1.00	Brick	Aug. 9		34,144.00	12,800.00
	58	Pleasants	5.4	Earth	Aug. 7		30,800.00	15,400.00
	59	Jackson	1.06	Concrete	Aug. 12		34,700.00	17,350.00
	62	Hardy	7.00	Gravel	Aug. 27		43,775.00	21,887.00
	63	Morgan	2.00	Concrete or bituminous	do		42,000.00	21,000.00
Wisconsin	26	Wood		Gravel		Aug. 12	[1] 15,027.08	[1] 15,009.03
	35	Dodge		Gravel or macadam		Aug. 4	[1] 4,459.59	[1] 1,486.52
	47	Vernon		Earth		do	[1] 11,205.38	[1] 3,735.12
	58	Outagamie	3.78	Concrete		Aug. 12	89,408.43	29,802.81
	60	Greenlake		Grading and concrete		Aug. 4	[1] 7,167.50	[1] 3,024.18
	77	Waushara	4.02	Topsoil		do	22,139.10	7,379.70
	96	Rock	6.15	Concrete	Aug. 11		164,890.00	54,963.33
Wyoming	38	Hot Springs	3.381	Gravel	Aug. 27		33,550.00	16,775.00
	39	Big Horn	8.161	do	Aug. 25		74,767.00	37,383.50
Total	234		1,944.41				30,397,337.96	12,362,585.99

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[1] Modified agreements. Amounts given are increases over original agreement.

[2] Modified agreements. Figures are a decrease from those in original agreements.

BRIDGE APPROACHES.

FOR various reasons it frequently is advisable to raise the floor of a bridge above the elevation which is the most elevation for the roadway leading to the bridge. The reasons for this do not need further discussion in this connection than to say that the most potent reason for such a difference in elevation when it occurs is the necessity of securing ample clearance between the maximum high-water level and the bridge structure in order to pass floating débris. However, the fact that these differences of elevation do exist, leads to the necessity of connecting the two elevations, that is, the bridge floor and the road surface, by a suitable ramp, concerning which a number of points deserve more attention than generally is given to them.

The first of these points is that economy in road design dictates that the elevation of the roadway should be selected without any reference whatever to the elevation of the bridge floor. The elevation of the roadway at any point is dependent on such factors as foundation conditions, drainage, gradient, etc., and when these conditions are satisfied, whatever addition is made in the height of an embankment must be recognized as involving additional risk to high speed traffic, additional construction cost and additional maintenance cost and, therefore, demanding full justification.

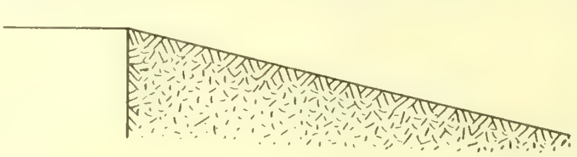
SHORT RAMPS MAKE FOR ECONOMY.

On the other hand, the logical result of all this is short ramps which, though somewhat to be condemned on the ground that they mar the beauty of the roadway are, nevertheless, in the interest of economy. This is particularly true where a bridge crosses a stream laying in a low, flat valley, the stream carrying enough drift to require rather a high clearance. In such cases the difference in elevation between the economical level of the road surface and the proper elevation of the floor of the bridge may be considerable and it is seldom economical or advisable to raise the road grade to the elevation of the floor of the bridge, as such a procedure would involve a considerable amount of expensive embankment. The obvious solution, then, is the construction of a comparatively short bridge approach and the real problem lies in the choice of a gradient for such approaches.

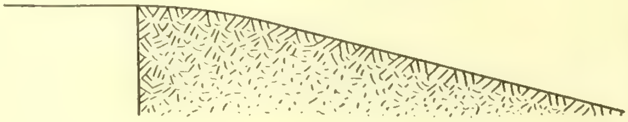
SHOULD BE BUILT FULL WIDTH.

The present tendency is to build bridge approaches on long easy grades, but this involves a heavy expense and tends to nullify the gain accruing from the independent selection of the proper elevation for the bridge floor and for the roadway. A better practice is to base the gradient of the approach on the ruling grade in force on other parts of the road. In other words, if there is a 10-feet difference in elevation between the normal position of the road surface and the proper elevation of the floor of the bridge and if 5 per cent grades are common throughout the length of the road, there is no particular reason for constructing the ramp connecting these two elevations on less than a 5 per cent grade, particularly as the shorter ramp will usually be less expensive and should be more easily maintained than a longer structure built on a light grade.

Ramps used for bridge approaches should be built full width. It frequently happens that where the shoulder width of the road proper is, say 24 feet, and the clear width of the bridge floor is 16 or 18 feet, the ramp is allowed to pinch down in width as the bridge is approached until there is a distinct constriction at and near the bridge. It is much better practice to provide abutments which will enable the use of full width ramps, or if this is, for any reason, inadvisable to fence approaches which are of any considerable height.



IMPROPER BRIDGE APPROACH.



PROPER BRIDGE APPROACH

PROPERLY EASED APPROACHES.

Finally, breaks in grade between bridge approaches and the elevations which they connect should be eased by the use of vertical curves under the same rules which apply to breaks in grade at other points along the highway. The use of easement curves will somewhat increase the length of bridge approaches because of the necessity of building the whole of the easement in the approach. However, this is not a matter of great importance and the added cost is more than justified by the fact that approaches which have been properly eased are a distinct assistance in driving onto and off of a bridge structure. Moreover, they make the maintenance of a road at the bridge very much simpler.

NEW METHOD FOR ADJUSTING EARTH EXCAVATION AND DETERMINING HAUL.

By J. W. Ball, Highway Engineer, and C. R. Shore, Highway Draftsman, Bureau of Public Roads.

EVERY highway engineer who is striving for economy in highway design finds that his greatest problem lies in the adjustment of his grade line so that he can avoid unnecessary earth work. The amount of surfacing which he must use is rather arbitrarily determined by the length of the route selected and is all but independent of the gradients finally adopted. Similarly, the number and the size of the drainage structures is determined, almost entirely, by the location and is quite independent of the gradients used. These, with the earth work, make up the three major portions of the cost of any highway but, differing essentially from the other two in this respect, the quantity of earth work can be modified, to a very marked extent, by modifications in the grade line, no matter what location is chosen. Economy of design, therefore, dictates that the gradients which are finally selected not only meet general engineering requirements, but that, as far as possible, all economies which do not involve a conflict with general engineering principles be adopted.

METHODS ARE USEFUL.

With this thought in mind, the following discussion of a graphic method of adjusting excavation and of determining overhaul is presented. The methods described are believed to be original, but whether original or not, it is felt that their usefulness justifies their presentation at this time and that their careful study and more general adoption by highway engineers will result in noticeable savings in the cost of excavation. On the other hand, it is recognized that these methods are not competent to correct improper location nor do they suffice to determine the most economical general adjustment of the grade line. They do, however, suffice to indicate local changes in grade alignment which are in the interest of economy. The changes worked out may or may not be in keeping with general engineering principles, and where this method is adopted it is, therefore, necessary to caution those who use it that the changes which this method develops as in the interest of economy may have to be rejected as in violation of major engineering principles. An illustration of this fact would be the development, by the use of this method, of the fact that a shorter curve should be adopted at a point where the minmum has already been selected, or that a short adverse grade in a long ascending grade would save excavation. In either case an engineer would hesitate to follow the dictates of economy and should, in fact, reject the information developed as of no value, more important considerations preventing its use.

These and other cases will occur where the information developed can not be used but they serve simply as an illustration of the general statement that this system is an assistance in the proper adjustment of highway grade lines, not a panacea to be applied for the elimination of excessive costs rightly chargeable to poor location or to improper general assumptions as to the laying in of the grade line. The discussion follows:

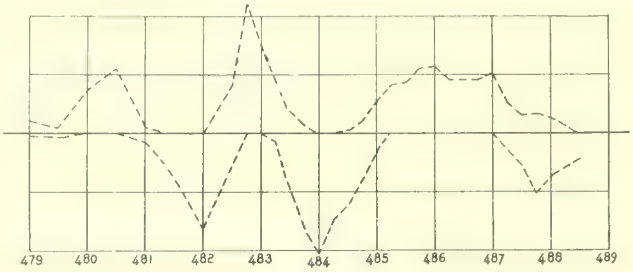


FIG I
QUANTITIES DIAGRAM

THE QUANTITIES DIAGRAM.

The "quantities" diagram, as applied to highway design, consists of two curves obtained by connecting the two series of points which result if the stations are platted as abscissas and the corresponding end areas of excavation and embankment, respectively, as ordinates. Excavation is platted positive, and embankment negative. The excavation curve would then always appear above the horizontal axis (or coincident with it wherever there is no excavation), and the embankment curve would appear below the horizontal axis (or coincident with it, where there is no embankment). With end areas platted in square feet and the stations and fractions thereof in linear feet (see Fig. 1), the area included between the horizontal axis and the curve which lies above it represents the volume of excavation, while the area included between the horizontal axis and the curve which lies below it represents embankment, both in cubic feet.

These areas are readily found by a planimeter and by using a horizontal scale of 1 inch to 100 linear feet and a vertical scale of 1 inch to 100 square feet, 1 square inch on the "quantities" diagram represents 10,000 cubic feet of excavation or of embankment, as the case may be.

This "quantities" diagram furnishes a quick and accurate means of determining the quantities for preliminary estimates, but, more important still, it presents a useful yardage curve to be studied in connection with general grade revisions, since it shows the location and amount of earth work at all points along the line. These curves are particularly useful in locating sections of a highway which are grossly out of balance, for the predominance of cut or of fill over any section of a highway is very noticeable. These curves do not, however, give any indication as to whether the failure to secure a balance is due to a general policy of doing too much cutting or of calling for too much filling or is caused by a failure to make proper use of the maximum grade. These curves simply indicate where a lack of balance exists. The question as to whether this lack of balance is to be corrected at all and, if so, what methods are to be adopted, is one of engineering judgment which can not be assisted by any set formula.

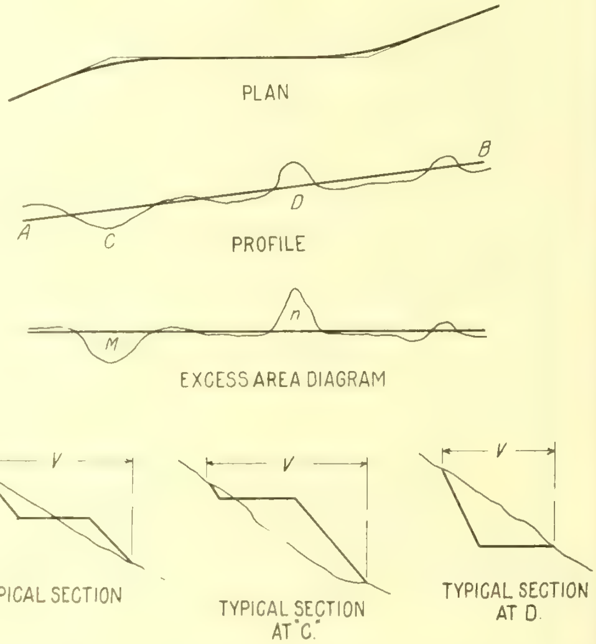
THE EXCESS AREA DIAGRAM.

The "excess area" diagram is the algebraic sum of the excavation curve and the embankment curve of the "quantities" diagram. Excavation excess is platted as positive and embankment excess is platted as negative and the line stations are platted along the horizontal axis as before. In this graph the ordinate for each station is in square feet and is the difference in square feet between the excavation included in the end area and the embankment included in the end area for that station. This is platted as positive if the excavation exceeds the embankment and as negative if the embankment exceeds the excavation. Where the road is all in cut or all in fill the "excess area" curve will coincide with the quantities curve but where, as in side hill work, cross sections include both cut and fill, the "excess area" curve will fall between the two curves of the quantities diagram. Moreover, wherever the cut and the fill are equal, the "excess area" curve will intersect the horizontal axis, from which it naturally follows that, on a hillside location, where an ideal location would cause the cut along any section to exactly make the fill along that section, the excess area curve will be a straight line coinciding with the horizontal axis. Any deviation from such a location causes the excess area curve to separate from this horizontal axis.

The excess area diagram therefore shows to what extent the location of the grade line varies from this ideal line. Moreover, the area below the excess area curve and above the horizontal axis represents the volume of excavation in excess of that required to make the corresponding fill along this portion of the line and the area below the horizontal axis but above the excess area curve represents the volume of embankment which is in excess of that produced by the excavation over that section. The excavation and the embankment on any given length of a project are, then, theoretically balanced when the plus and minus areas on the excess area diagram are equal over this length of the project. The quantity to be hauled is also accurately and clearly shown and the distance of the haul can be closely approximated.

Whenever an allowance is to be made for shrinkage it is advisable to increase the embankment areas by the customary per cent (which usually varies from 15 to 25 per cent of the volume of embankment in common excavation) before calculating the difference between excavation and embankment. The amount of increase to be used is generally fixed by established rules but may, in the absence of fixed rules, be adjusted according to the judgment of the engineer.

FIG 2.



USE OF THE EXCESS AREA DIAGRAM.

The road location having been made in the usual way, and the end areas from cross sections having been obtained from a tentative grade line, to apply the excess area diagram in the design of the road, first plat the quantities diagram, using for this purpose the information secured from the cross sections for the tentative grade line. Any gross errors in the balance will be shown by the quantities diagram and the first step should be to secure a decision as to their adjustment. If they are to be eliminated, the grade line should be relaid and the quantities diagram redrawn until there is some approach to a balance between controlling points. The excess area diagram should then be drawn and the work of refining the grade line may proceed. This refinement of the grade line will involve minor changes in the position of the line; that is, pushing it into or pulling it out of the hill on sidehill work, or minor changes in the established gradient. These will be discussed independently.

ALIGNMENT REVISIONS FOR BALANCING QUANTITIES.

Assuming now a section of sidehill road of profile AB (see fig. 2) with a typical cross section as S and with the elevations of A and B as fixed or controling points, then naturally the desirable grade line would be unbroken, that is, would show no reverse grades from A to B.

If a location made from A to B on the plan and profile as shown in figure 1 results in an excess area diagram as shown in this figure, and if the excavation on the section as a whole is practically in balance it is at once apparent that points C and D vary from the economical location by the excess embankment *m* at C, and the excess excavation *n* at D, and that if the balance is preserved the excess excavation at D must be hauled to C. The problem then is to revise the alignment at C and D so that the excess area curve will approach as closely as possible to its most economical position, that is, the horizontal axis, and to do this without disturbing the balance on the section, AB, as a whole, and without introducing any improper gradients.

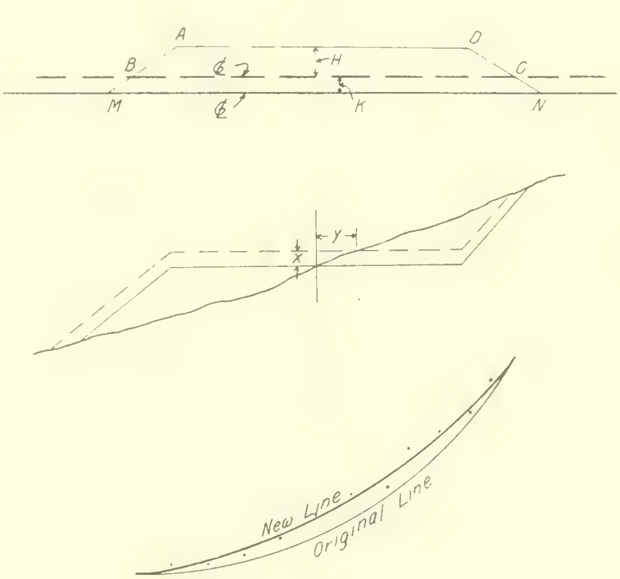
On a sidehill location, pulling the alignment out of the hill has the same effect on the quantity of earthwork as raising the grade. Similarly shoving the line into the hill has the same effect as lowering the grade. If now the effective width of a cross section is defined as the horizontal distance V (see typical cross section fig. 2) between the intersections of the original ground slope and the ditch slopes, then the result of a change in the elevation of the grade depends upon the effective widths of the cross sections involved.

Thus (see fig. 3) assume a fill on level ground. The area of the cross section is $\frac{AD+BC}{2}\times H$. If this fill is increased down by a height Y the area becomes $\left(\frac{AD+BC}{2}\times H\right)+\left(\frac{MN+AD}{2}\times Y\right)$. The reverse of this holds true if the height of the fill is decreased. This same also holds true if part of the section is in cut and part in fill, the fill being increased by raising the grade line and decreased by lowering the grade line by the average width of the bases times the amount of the change in grade. But *AB* is the same as V in the type figures, MN is the same as V′ and Y the same as *g*. There results the general deduction that for any change in grade, the change in excess area of the cross section equals $g\,\frac{(V+V')}{2}$, which is positive when the grade is raised and negative when the grade is lowered. For small changes in grade elevation V′ may be assumed as equal to V and the equation there becomes *g*V. For changes of grade elevations exceeding half of a foot the average effective widths should be determined by scaling the cross sections.

CHANGES IN CENTER LINE POSITION.

At points such as C and D in figure 2 the change required in grade elevations at each cross section, if an economical balance is to be secured is easily computed in feet as will be more clearly brought out later on. However, it is often inadvisable to make adjustments by means of local changes in grade and, on hillside locations, a similar result can be secured by moving the center line a corresponding distance from or into the hill so that the required lowering or raising of the ground surface results. The amount of this lateral movement (see fig. 3) is easily determined. Raising the grade line reduces the excavation and increases the fill. By an inspection of figure 3 it will be clear the primary effect of raising the grade line a distance *x* is to throw the center line out of the hillside a distance *y*. If on the other hand embankment is to be decreased, the line must be pushed into the hill. This distance *y* may be determined for any cross section by platting on this cross section the change of elevation which has been calculated as necessary to accomplish the desired change in excavation or in embankment and scaling *y*. To determine the desirable change in the position of the center line over any section of the highway, the *y* distances are platted as shown in the plan figure 3 and a new curve laid which will as nearly as possible average these points.

FIG. 3.



PLAN

It is seldom possible to achieve what would theoretically be the most economical location, for in rounding points maximum grades must be considered and excess excavation must be provided to make the embankments in the gullies. Moreover, the closeness of the approximation of the alignment to its most economical location is governed by general conditions as to maximum grade, maximum radius, length of line of sight, etc., but the excess area diagram is of much help in adjusting the grade within the limits imposed by such requirements.

GRADE REVISIONS FOR BALANCING QUANTITIES.

Consider a profile as shown in figure 4 and for convenience assume a level ground line, and excavation and embankment section 10 feet wide with vertical slopes. Then the area of the cross section is directly proportional to the depth of the cut or fill, and in this special case the cross-section area is always either (1) all excavation, (2) all embankment, or (3) zero.

With the original grade line as shown at EF in figure 4 the excess area diagram is platted as in figure 5 and shows that the excess excavation for a 10-foot width of cross section is 60,000 cubic feet and the excess embankment 20,000 cubic feet. The balance is, therefore, 40,000 cubic feet, deficient in embankment, no account being taken of shrinkage. Assume that it is desirable to raise the grade line parallel to itself, but that, on account of local conditions, it must be broken at G and H to connect with the former grade at E and F. Let M be the vertical ordinate representing this change as it will appear on the excess area diagram, that is the average required change in the area of cross section in square feet. Then, since $\frac{AB+CD}{2}$ is the average length of the trapezoid ABDC in figure 3, to determine the vertical ordinate or its equivalent the required change in cross section, there results the equation

$$M=\frac{40,000}{\frac{AB+DC}{2}}=\frac{40,000}{\frac{1,000+600}{2}}=50$$

which is the average change in cross section required to produce the desired result.

On a cross section 10 feet wide, as assumed, a change of 50 square feet in end area is secured by a change of 5 feet in grade elevation. Hence the grade line from G to H, figure 4, should be raised 5 feet, the grade EGHF resulting.

After this change in grade line is made, the resulting excess area diagram may be plotted, as in figure 6, which is a rectification of figure 5 about ACDB, which line thus becomes the new horizontal axis and the quantities are found to be balanced within ordinary working limits of accuracy.

With similar conditions as to vertical slopes and width of cross section figure 7 is a profile with a tentative grade line placed at EF, which yields the excess area diagram shown in figure 8. The excavation is considerably out of balance. It is desired to balance the quantities by raising the grade line at one point as G. In figure 8, ACB illustrates the effect of this change on the corresponding excess area diagram. But

$$M=\frac{\text{Deficiency of balance}}{\frac{AB}{2}}$$

and

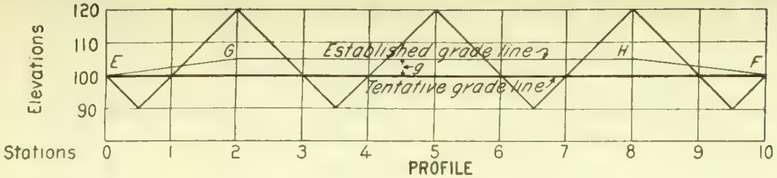
$$g=\frac{M}{\text{Average area of cross section}}$$

Proceeding as before, figure 9 is the excess area diagram with the new grade line EGF as the axis. However, this adjustment involves a long haul between station 2 and station 9+50 and to further adjust the grade line to eliminate this haul the line of balance of the excess area diagram should be revised. By proceeding as before the excess area diagram (fig. 9) is modified to show a new balance along AONB and the grade line is revised to EG′H′F in figure 7, g' and g'' being computed as indicated above. The excess area diagram may then be plotted again as in figure 10, which is a rectification of the excess area diagram about the grade line EG′H′F, which shows that the quantities are in balance with a minimum haul. When familiar with the method of procedure one makes the first revision from the quantities diagram and the final revision generally without a preliminary trial.

In actual construction, because of the approximation in determining the effective widths of cuts and fills, it is sometimes found that after revision the quantities are still somewhat out of balance. In this case by using two trial excess area diagrams, one can interpolate for the real balance very accurately.

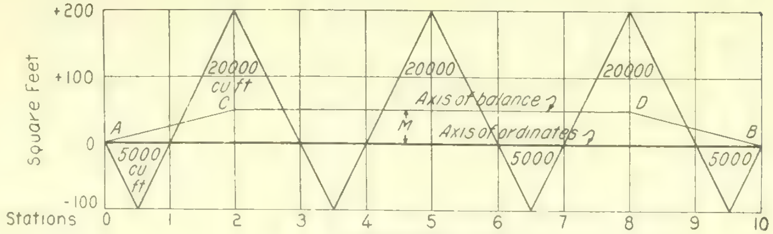
OVERHAUL OF EXCAVATION.

"When the distance between the center of mass of any cut and the center of mass of the corresponding embankment exceeds 1,000 feet, all of the material obtained from the cut and used in the embankment shall be known as 'overhaul excavation', and the length of overhaul shall be measured as the distance between center of mass of cut and center of mass of fill, minus 1,000 feet." [From U. S. Bureau of Public Roads, Typical Specifications.] This defines the method by which overhaul shall be calculated in making final payment for overhaul, and where this definition is used it must be adhered to strictly in making final payments to contractors. However, for other purposes, the center of volume of excavation to be



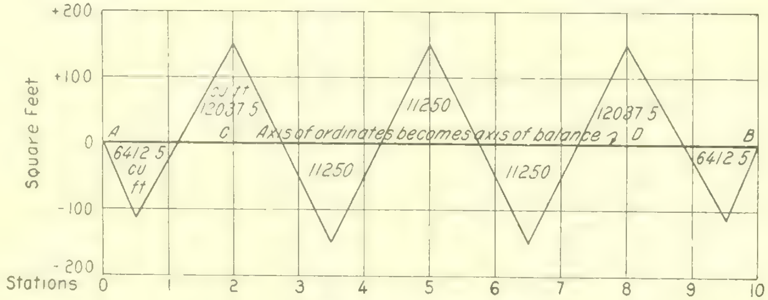
PROFILE

FIG. 4.



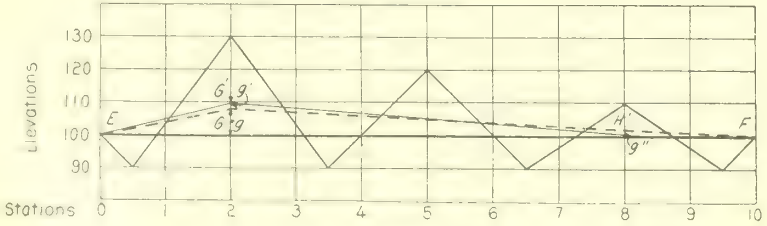
EXCESS AREA DIAGRAM

FIG. 5.



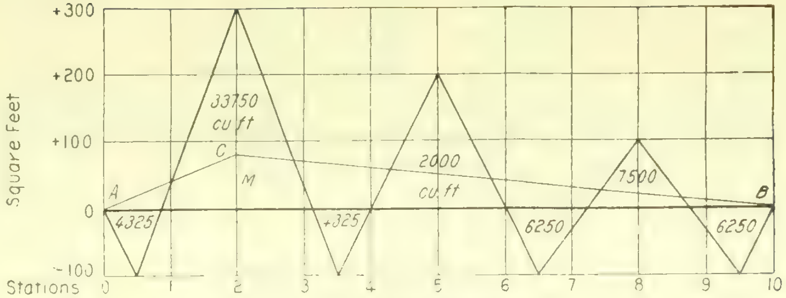
FINAL EXCESS AREA DIAGRAM

FIG. 6.



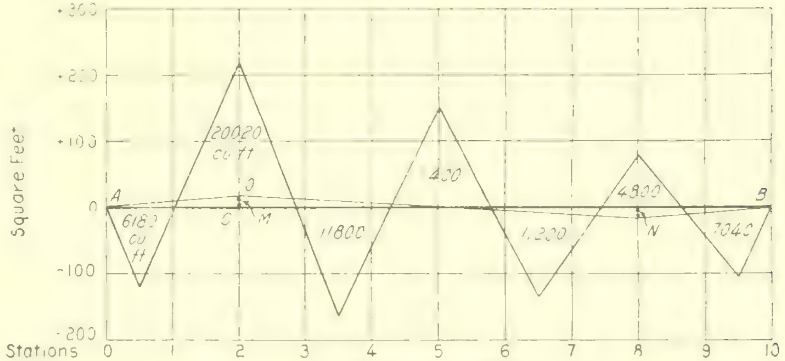
PROFILE

FIG 7



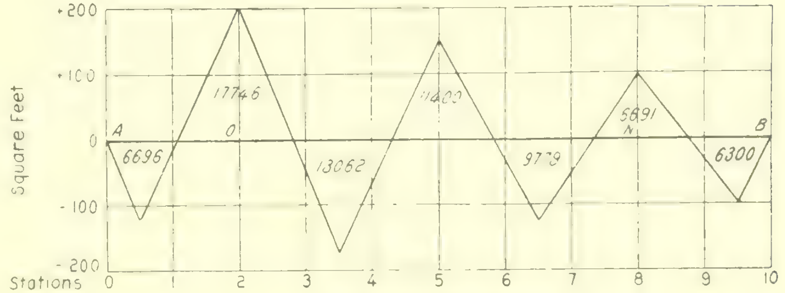
EXCESS AREA DIAGRAM

FIG 8



EXCESS AREA DIAGRAM

FIG 9



FINAL EXCESS AREA DIAGRAM

FIG 10

hauled and the center of volume of the corresponding embankment may be approximately determined by inspection from the excess area diagram and a close approximation of the overhaul readily calculated.

If it is desired to determine the center of volume of any excess either of embankment or of excavation, the excess excavation or embankment may be divided by vertical lines, and the areas on each side of each line can be measured by a planimeter. In this way an approximate center of volume can be quite rapidly calculated. Overhaul is the distance between the center of volume of the excavation and of the corresponding embankment less the free haul multiplied by the quantity moved. This method is much easier and quicker to apply than that of the mass diagram, and while, as stated above, not legal for computing final estimates, is satisfactory for grade adjustments, estimates, and even for intermediate vouchers.

APPLICATION TO AN ACTUAL CASE.

Figure 11 is the profile from station 475 to station 495 of the Canyonville-Galesville section of the Pacific Highway now under construction. This section is a complete balance within itself, as the material up to station 474+80 hauls back. The actual working out of this method is shown in figures 11, 12, 13, and 14.

Figure 11 is the profile, figure 12 is the quantities diagram, and figure 13 is an excess area diagram for this section of highway, as calculated from the tentative grade shown by the dashed line in figure 11. This tentative grade line failed to give a balance of excavation, as is seen from the quantities diagram, figure 12. Before revision to balance excavation and embankment the location of excess excavation and of excess embankment was examined with respect to both quantity and haul. From this examination it was evident that, for economy, the embankment from station 475 to station 485 and from station 487 to station 490+50 (see fig. 12) should be decreased. This defect was corrected by making two changes in grade line.

THE FIRST CHANGE.

This change of grade line extends from station 475 to station 485. Assuming that half of the fill at station 484 is to be hauled from the cut at station 486, the excess embankment from station 475 to station 485 equals (27,050+16,150+9,700) cubic feet=52,900 cubic feet total.

The excess excavation on the same section equals (15+3,600+7,200) cubic feet=10,815 cubic feet total.

52,900−10,815=42,085 cubic feet which is the deficiency in excavation.

On this subsection of line it was decided to lower the grade parallel to itself, as shown in figure 11. The resulting effect is shown by figure ABDC in the excess area diagram of figure 13. In order that the excavation may balance, the area of ABDC must represent 42,085 cubic feet of earthwork, which is the amount of the deficiency in the excavation. The lengths of the two sides AB and CD of the figure ABDC are determined from figure 13. Then, if, as above, M represents the average change in area of cross section (vertical ordinate) in square feet needed inorder to adjust the balance,

$$M=\frac{42{,}085\text{ cubic feet}}{\frac{AB+DC}{2}}=\frac{42{,}085}{800}=52.6\text{ square feet.}$$

Next, the average effective width of the cross-sections involved, determine by scaling and averaging all stations from 475 to 485, was found in this case to be 26.3 feet.

Then g, the amount the grade is to be lowered, is equal to $\frac{52.6}{26.3}=2$ feet.

This change in grade line having been made as shown in figure 11, the resulting excess area diagram was shown as C. D. B. F. in figure 13.

THE SECOND CHANGE.

This change in grade line extends from station 481 to station 494+50. The quantities were balanced by lowering the grade line near station 492+50 as shown in figure 11 by g'. The effect is shown in figure 13 by the line EGF. It is noticed that the change represented by EHB, which is a part of EGF falls in the figure representing the first grade change just described. The line DHK represents a further shifting of the axis of balance CDB which resulted from the first change, the axis finally becoming CDKGF.

To determine the grade change from station 481 to station 494+50 the following calculations were made. The excess embankment includes one-half of the fill at station 484 and is, therefore (9,700+21,730+212+12+13,150), cubic feet=44,804 cubic feet total.

The excess excavation is equal to (15,700+334+650+1,600) cubic feet=18,284 cubic feet total. But 44,804 cubic feet−18,284 cubic feet=26,520 cubic feet which is the total deficiency in excavation.

Therefore

$$M=\frac{26{,}520\text{ cubic feet}}{\frac{EF}{2}}=\frac{26{,}520}{\frac{1{,}350}{2}}=39.29\text{ square feet.}$$

The average effective width of the cross sections involved (as determined by scaling the plotted sections) is 28 feet; therefore, $g=\frac{39.29}{28}=1.4$ feet,

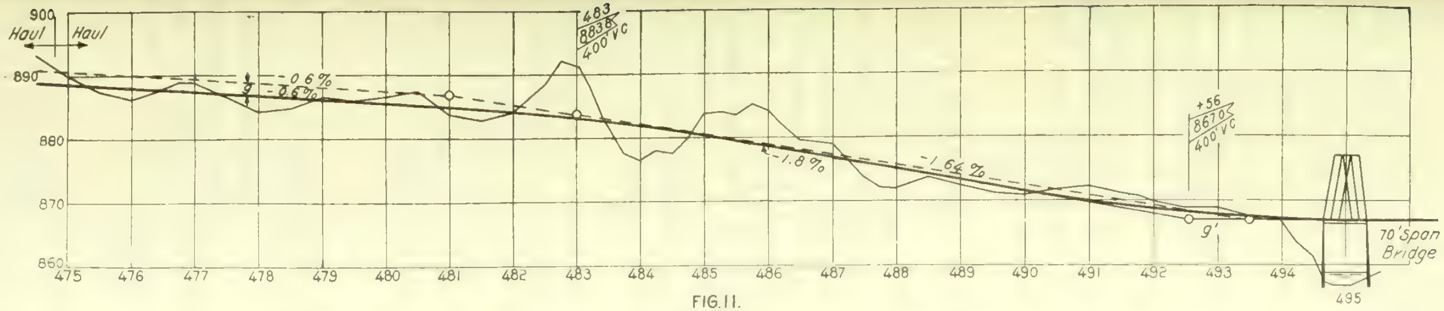


FIG. 11.
PROFILE

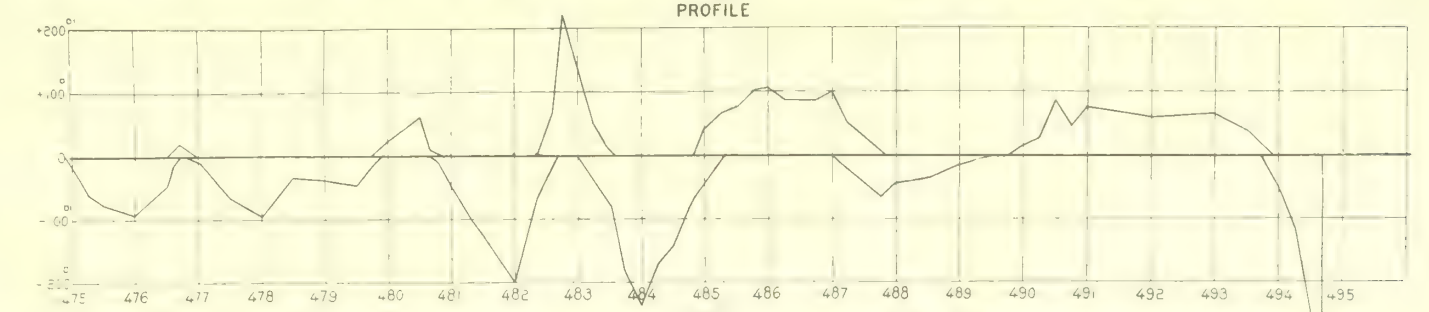


FIG 12.
THE QUANTITIES DIAGRAM

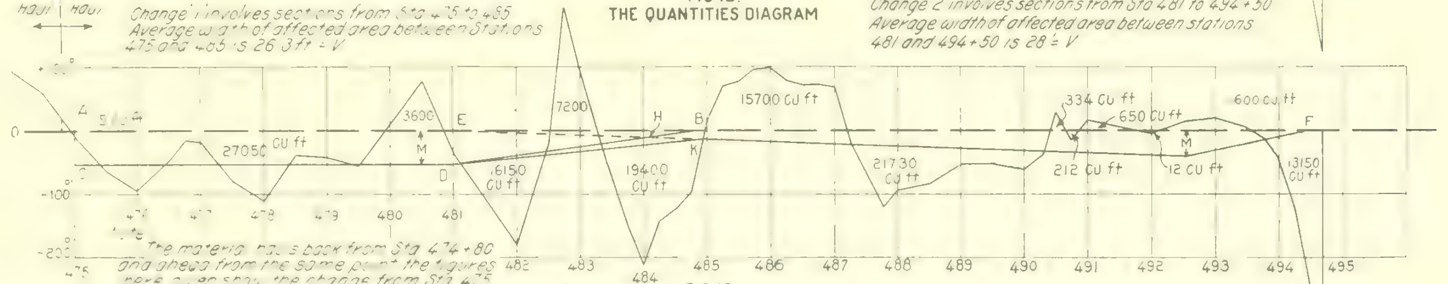


FIG 13
THE EXCESS AREA DIAGRAM

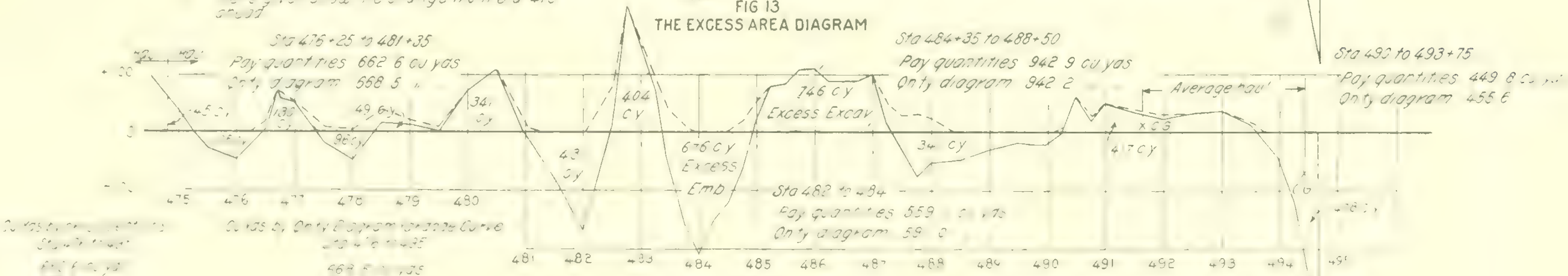


FIG 14
THE FINAL EXCESS AREA DIAGRAM

which is the change in the elevation of the grade line at *g*.

Figure 14 is the final excess area diagram plotted after the grade line was revised and shows a balance of earthwork quantities. In this figure the quantities diagram is also shown by dashed lines. Comparative results of measurement of quantities and of computation of quantities for the line as finally laid in are also shown.

At first thought the use of such a method as this may seem tedious and expensive but an examination of the results obtained on this short section of highway, a length of about 20 stations, or roughly two-fifths of a mile, will serve to justify thoughtful consideration of this system. The line as originally laid in (see fig. 11) was a carefully laid line but computation shows that it produced about 2,500 cubic yards less cut than fill. The revised line, on slightly better grades, shows 2,657.3 cubic yards to be paid for as excavation (shrinkage allowed for in drawing quantities diagram and excess area diagrams). The net saving in earthwork which resulted from the changes shown was approximately 1,500 cubic yards or, at 50 cents per cubic yard, the tidy sum of $750.

It is confidently believed that similar savings can be made by all who will familiarize themselves with this method and that these savings will be more than sufficient to justify a thorough mastery of the ideas here outlined.

PENNSYLVANIA MOTOR LAW.

Pennsylvania's new motor vehicle law provides that no motor vehicle can be registered which has an outside length exceeding 336 inches and an outside width exceeding 90 inches. The provision does not apply, however, to vehicles registered or contracted for prior to the passage of the law. The gross weight is limited to 26,000 pounds. Registration fees are 40 cents for each horsepower, with a minimum of $10.

Registration fees for commercial vehicles are:

Class AA, weight of chassis 2,000 to 2,999	$20
Class A, weight of chassis 3,000 to 4,499	25
Class B, weight of chassis 4,500 to 5,999	30
Class C, weight of chassis 6,000 to 6,999	50
Class D ,weight of chassis 7,000 to 7,999	75
Class E, weight of chassis 8,000 to 9,999	100
Class F, weight of chassis 10,000 and over.	150

No registration is required for a trailer weighing less than 500 pounds For trailers weighing 500 to 749 pounds the fee is $2, 750 to 999 pounds $5, 1,000 to 1,999 pounds $10, 2,000 pounds or more $15. For all vehicles equipped with metal tires the fee is double.

Motor cycle dealers must pay a license of $5 for each certificate and number plate and motor vehicle dealers $10 for each certificate and two number plates.

All operators of cars must have a license. A driver's license is $2, an operator's $1, and a learner's 50 cents. Drivers and operators must be over 18 years of age and learners over 16.

No commercial vehicle may be operated on the public highways the weight of which with load exceeds 7,000 pounds for class AA, 11,000 for class A, 15,000 for class B, 20,000 for class C, 24,000 for class D, and 26,000 for classes E and F. The weight of trailers must not exceed 26,000 pounds nor 19,200 on any axle nor 800 on any one wheel for each nominal inch of width of tire, or which exceeds 336 inches in length over all or 90 inches width over all.

Extreme speed of cars is limited to 30 miles an hour, classes AA and A commercial cars to 20, class B 18, classes C and D 15, class E 12, and class F 10 miles.

MAY LET SEPARATE CONTRACTS.

In reply to an inquiry from the State engineer of New Mexico relative to the construction of a Federal-aid project through two contracts, one for all the work except the surfacing and a second contract for the surfacing, instead of providing for the work through a single contract, it has been ruled that the plan is permissible, provided that the two contracts are so let that the project may be completed within a resonable time. The plans, specifications and estimates should show the project as being surfaced and include the necessary items in the detailed estimate upon which the project agreement will be signed. The plans, specifications and estimates can then be put through in the ordinary way, and all the work advertised except the surfacing, and that contract completed and a second contract let for the surfacing.

MAINE VOTES BONDS.

On September 8 Maine, by a vote of about 5 to 1, indorsed the proposal to raise the bonded indebtedness for State highways from $2,000,000 to $10,000,000. This will give $8,000,000 additional to be spent on the State road system.

NEBRASKA ROAD DISTRICTS.

The Nebraska State highway department has created five districts for the administration of road work and made an allotment of the State funds to them. The allotments run from $1,373,886.73 to $3,346,666.99.

COMPREHENSIVE INVESTIGATIONS IN HIGHWAY ENGINEERING NEEDED.

By T. R. AGG, Iowa State College.

THE highway engineers of the United States face the necessity of undertaking an enormous construction program immediately. Economic pressure and popular demand alike necessitate a vigorous campaign of road building, both in the States that have been actively building roads for years and in those States that have heretofore seriously neglected road improvement. Not only will the program, as tentatively outlined for 1920, seriously tax the engineering organization if suitable plans and specifications are prepared, but highway contractors and material supply companies are likely to find that their capacities will be taxed to the limit.

NO ADEQUATE BASIC THEORIES.

During the past 10 years, the transition from horse-drawn to motor traffic has been so nearly complete that horse drawn-traffic can no longer be considered a controlling factor in highway design; yet practically all of the basic principles of highway construction were evolved for horse-drawn traffic. These have been modified from time to time as experience has indicated defects, but for the most part local conditions have been so large a factor that types and designs which have been satisfactory in one State have proven entirely unsatisfactory in another.

To a large extent, the tests for the materials used in highway construction were developed under horse-drawn traffic conditions and these also have been revised and new tests devised to meet the new conditions, and yet it is now recognized that many of the tests in current use are not entirely satisfactory.

The situation then is this: The United States is entering upon a very extensive highway construction program without an adequate, acceptable economic theory or group of theories upon which to base design, selection of routes, and types of construction. Knowledge of tests and properties of materials have not advanced to the extent necessary to enable highway engineers to proceed with certainty.

It seems imperative that investigation in the field of highway engineering be prosecuted with the utmost vigor during the next few years, else it will be found that much of the money expended for highway improvement has not secured highways of the maximum serviceability because the design and the requirements for materials were based on unsound theories or inadequate tests.

TO SECURE SERVICEABLE ROADS.

Basic theory, if there is any, for a science as complex as the building of a system of highways for a nation can not be evolved overnight except in the fertile brain of the professional good roads enthusiast of the parasite type, and no two of them agree. Years of painstaking research on the part of many men are required to secure the data upon which theories may be based. Likewise, the correlation of tests for materials with actual results obtained with the materials under service conditions requires the accumulation of data for years before dependable conclusions can be reached.

There is at the present time an urgent need for the inauguration of a far sighted, comprehensive program of investigation of materials and methods of construction now employed in highway improvement. How can such a program be arranged for with reasonable certainty that it will be carried through?

DIFFICULTIES OF THE PROBLEM.

Nearly all of the State highway departments are loaded down with the practical problems involved in carrying through successfully a large construction program. Some have done excellent research work in limited fields, and a few are still attempting to maintain some experimental work.

Through the standing committee on tests and investigations of the American Association of State Highway Departments, an attempt is being made to make available to all State highway departments the results of any investigations completed by any one of the departments. But at best the State highway departments can scarcely touch the field.

Many of the land grant colleges maintain agricultural experiment stations, which are at least partly supported by Federal appropriations, and these stations, in cooperation with the United States Department of Agriculture, have done excellent work. There seems to be no reason why engineering experiment stations should not be maintained in the same way, and if they were interested in the investigation of highway problems, they should be able to contribute enormously to the solution of the many problems now confronting the road builder. Some States now support engineering experiment stations that have done splendid work, and the only bar to similar results at other institutions seems to be lack of financial support.

The recently organized National Research Council is making an effort to stimulate research in the highway field, and should prove to be an important agency in directing efforts so as to prevent duplication and in interesting investigators in the problems requiring solution.

HOW THE WORK MAY BE DONE.

But none of these agencies seem to possess the permanency and financial backing necessary to prosecute a program of investigations adequate to the present needs in the highway field. It is highly important that there be a continuing policy, for a term of years, through an agency of sufficient prestige to secure cooperation throughout the United States, and having sufficiently close connection with the actual construction activities of the several States to insure a wise selection of projects.

The Bureau of Public Roads of the United States Department of Agriculture would seem to be the logical agency to take the lead in this work. The bureau has already done a large amount of research work in this field and has trained investigators for carrying on the work and for passing on projects submitted for action. Through cooperation with the National Research Council, the bureau could probably secure the active participation of engineering experimental station laboratories.

But most important of all, the bureau is in close touch with the highway work in the various States and is in a position to judge as to the problems most imperative of solution and to secure the assistance of the State highway departments in those problems requiring the actual construction of surfaces or structures.

Surfaced highways of the maximum serviceability can not be constructed if engineers are compelled to guess at the basic principles involved nor if they are unable to determine accurately the suitability of materials. The Bureau of Public Roads can do no more valuable service than to secure, by whatever means it can devise, the scientific investigation of the various problems requiring solution before engineers can proceed with certainty in the construction of public highways.

MEMORANDA ON MR. AGG'S ARTICLE.

I have read with very great interest the short but inclusive article by Mr. Agg on the present great American highway problem, and the necessity of extensive investigations if some or all of the States are not to spend unwisely in the prosecution of the present tremendous road programs.

I agree thoroughly with Mr. Agg in his statements that the present facilities for highway engineering investigations are not adequate to meet the situation, or to develop the theories upon which the future science of highway engineering should be based.

It is to my mind certain that unless the United States Bureau of Public Roads builds up a good and extensive organization to prosecute these inquiries, that nothing of value can or will be done by any other existing organization.

I trust that the Secretary of Agriculture will see the advisability of an early attack upon this most important problem, and I believe that I am safe in pledging the cordial support of the American Association of State Highway Officials to the Secretary and to the bureau in this very great and necessary work.—*A. R. Hirst, President, American Association of State Highway Officials.*

$3,750,000 FOR ROADS.

St. Louis County, Mo., will spend $3,750,000 for county highways, this sum being derived from a bond issue and from State and Federal funds. The bond issue is for $3,000,000. The county highway engineer has been appointed by the county court to supervise the construction of the roads. He is now engaged in making the plans, which it is hoped will be ready to submit to the Bureau of Good Roads by October 1. Four roads are to be built. The roads will be partly concrete and partly bituminous macadam. Bids will be advertised during the coming winter so that work can start early in the spring.

VENTURA COUNTY BONDS.

Ventura County, Calif., on August 26, voted for the issuance of $480,000 of road bonds, making a total of $1,580,000 in two years.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Applications for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

*Report of the Director of the Office of Public Roads for 1914. 5c.
*Report of the Director of the Office of Public Roads for 1915. 5c.
Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.

BULLETINS.

(In applying for these publications the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28.")

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

*Dept. Bul. 53. Object-Lesson and Experimental Roads and Bridge Construction on the U. S. Office of Public Roads, 1912–13. 5c.
105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
24. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A Summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Prservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
*96. Naphthalenes in Road Tars. 1. The Effect of Naphthalene upon the Consistency of Refined Tars. (1911.). 5c.
*97. Coke-Oven Tars of the United States. (1912.) 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magniture on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. *239. The Corrosion of Wire Fence. 5c.
311. Sand-Clay and Burnt-Clay Roads.
338. Macadam Roads.
*403. The Construction of Concrete Fence Posts 5c.
*461. The Use of Concrete on the Farm.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given as " Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
*712. Sewage Disposal on the Farm. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D–2. Effect of Controllable Variables upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.

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BUREAU OF PUBLIC ROADS

Public Roads

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ASPHALT PENETRATION HIGHWAY, MASSACHUSETTS: BUILT 1914

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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ASPHALT IN ROAD CONSTRUCTION

By **JULES L. GOLDBERG**, Chief Editorial Division.

ASPHALT CONCRETE STREET AT NORFOLK, VA., 1914.

OF the materials used for road construction probably less knowledge of the properties and characteristics of the bitumens exists in the public mind than of any of the others. These bituminous materials may be divided into two classes—(1) those consisting of or containing petroleum or asphalt, and (2) those consisting of or containing tar products.

To the layman, asphalt and tar are only black, sticky substances. This is evidenced by the frequent tendency to confuse them or to use the terms synonymously. Although both are composed mainly of hydrocarbons and their derivatives, tar is a product obtained chiefly by the destructive distillation of coal in the manufacture of gas or coke or, in the case of water gas tar, by the cracking of oil vapors at very high temperatures, while asphalt is a semisolid or solid substance formed by the partial evaporation or distillation of certain petroleums. This definition applies whether such distillation or evaporation has occurred in nature, as in the case of the lake asphalts, or has been conducted as a refining process. The distinctly different nature in derivation of tar and asphalt and their different behavior when incorporated in a road makes it highly desirable that the two should not be confused.

ASPHALT AND ASPHALTIC PREPARATIONS.

It may be well to explain further in popular verbiage some of the terms used in connection with paving asphalt and asphaltic preparations. Thus a refined asphalt (R. A.) is one which has been brought into such a condition that it is suitable for direct use or may be made suitable by the addition of a flux. Asphaltic cement (A. C.) is an asphalt which is of suitable consistency for direct use in highway work. If a refined asphalt is too hard for direct use it is brought to a suitable consistency by combining it with a flux. When an asphalt is manufactured from petroleum it is usually made directly into an asphaltic cement, although it may, if desired, be turned out in a much harder condition. Crude native asphalt is almost invariably subjected to a refining process, which consists simply of removing the water and more volatile hydrocarbons and skimming off any vegetable matter which may rise to the surface of the melted material.

The flux used is generally a residuum produced from petroleum by distilling off the lighter and more volatile constituents. It may be mixed with melted refined asphalt in proper proportions to form an absolutely homogeneous fluxed asphalt or asphaltic cement (A. C.) of any desired consistency.

An asphalt cement of suitable consistency for a given purpose may be thinned to a fluid consistency with a volatile petroleum distillate, and the resulting product is called "cut-back" asphalt. Upon exposure this will rapidly become asphalt cement through evaporation of the light solvent. An asphalt cement may also be thinned to fluid consistency by the addition of water, provided an emulsifying agent, such as soap, is present in the mixture, and the resulting product is called emulsified asphalt. The term "liquid asphalt" is sometimes applied to a fluid petroleum product or road oil which is highly asphaltic in character and possesses the property of adhesiveness or stickiness to a marked degree. An asphalt petroleum is one which contains a considerable amount of asphalt dissolved in the lighter oils present and from which asphalt may be readily manufactured by evaporation or distillation to remove these light oils.

CHARACTERISTICS OF ASPHALTS.

The suitability of asphalt for road building purposes is determined by certain properties which long experimentation and observation have demonstrated to be essential. These properties or characteristics are indicated by the penetration, the ductility, the flash point, the loss by volatilization, change in consistency after subjection to heat test, the specific gravity and the solubility in stated solvents, usually carbon disulphide or carbon tetrachloride.

The hardness of an asphalt is expressed as penetration, which is a measure of the depth to which a standard needle will penetrate it at a standard temperature during a definite period of time when the needle is loaded with a known weight. Unless otherwise indicated, the temperature, weight, and time factors are understood to be 25° C. (77° F.), 100 grams, 5 seconds, and the units of penetration to indicate hundredths of a centimeter—thus, a 50 penetration asphalt is one in which the standard needle under standard test conditions penetrates to a depth of 50 hundredths of a centimeter. Thus, the softer the asphalt the higher is its penetration.

The ductility is expressed as a measure of the distance which a standard briquet of the asphalt will stretch without breaking, at a standard temperature, when the ends of the briquets are pulled apart at a definite rate of speed. The temperature is usually specified as 25° C. (77° F.) and the rate of speed as 5 centimeters per minute. Ductility is then expressed as the number of centimeters which the test specimen will stretch without breaking.

The flash point of an asphalt is that temperature at which it evolves vapors which ignite upon contact with a flame. This temperature should be higher than any to which the asphalt should be heated during its application in highway work.

The loss by volatilization of an asphalt is the per cent by weight which it loses when a sample is heated and maintained at a temperature of 163° C. (325° F.) for a period of 5 hours under standard conditions of test.

The determination of specific gravity and solubility needs no amplification.

ASPHALT CEMENT SPECIFICATIONS.

The consistency of asphalt cement as determined by the penetration test should be varied in accordance with conditions of temperature, traffic, and the type of pavement in which the asphalt cement is to be incorporated. The following table gives the Bureau of Public Roads' penetration limits for different types of pavement under different conditions:

Penetration limits for different types of pavements.

Type of road.	Location.	Penetration at 25° C.
Asphaltic macadam	Northern United States	120–150
Do	Middle belt, United States	90–120
Do	Southern United States	80–90
Asphaltic concrete, coarse graded	Northern United States	70–80
Do	Southern United States	60–70
Asphaltic concrete (Topeka type)	Northern United States	60–70
Do	Southern United States	50–60
Sheet asphalt	Northern United States	50–60
Do	Southern United States	40–50
	Heavy traffic, Northern United States.	....

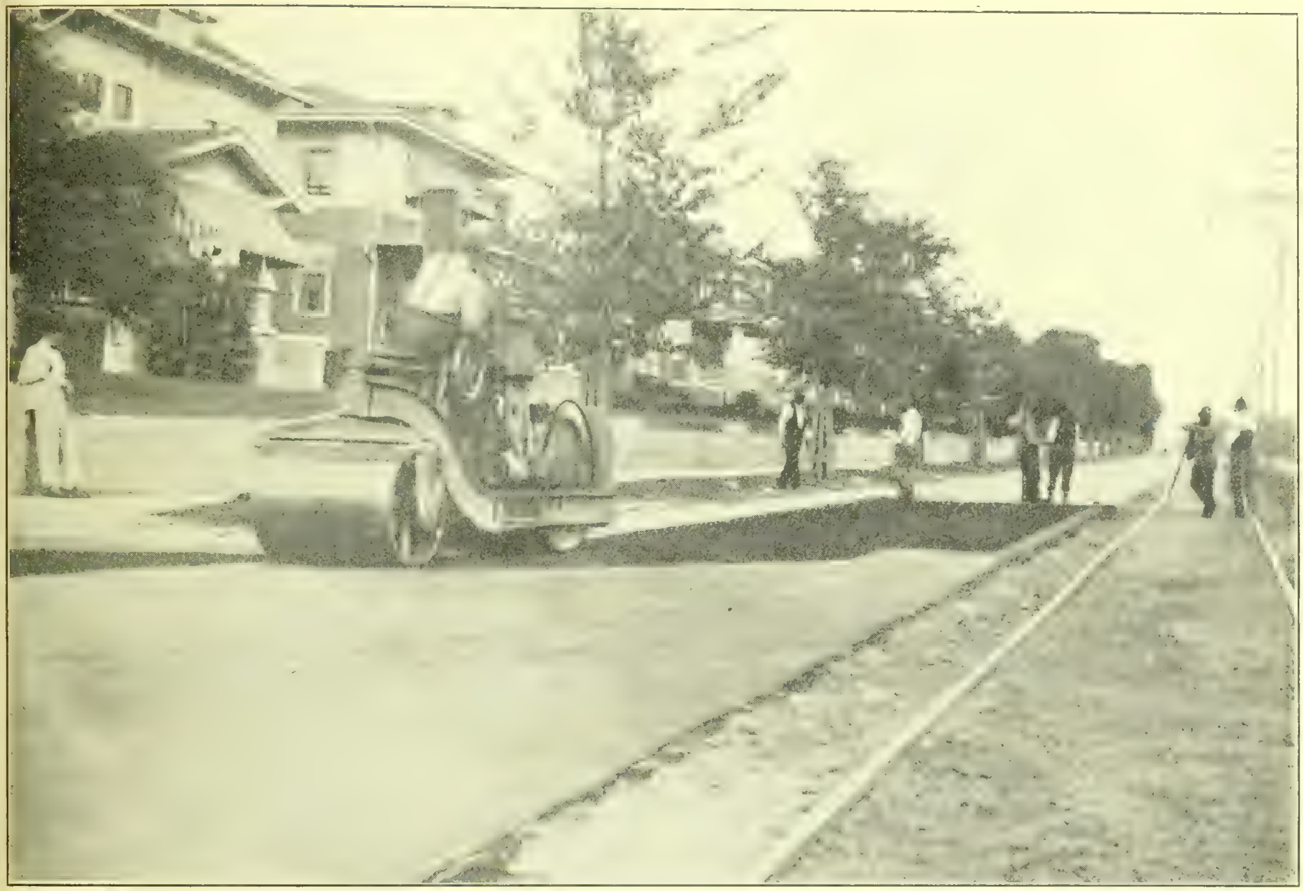
These penetration limits are only general, and in cases where special conditions of climate, traffic, and nature of stone are to be met it may be necessary to vary these limits.

TYPES OF CONSTRUCTION.

The most common types of roads and pavements in which asphalt serves as a binder are asphalt macadam, asphaltic concrete, sheet asphalt, and asphalt block.

Asphalt macadam.—The maximum value of asphalt macadam for relatively heavy traffic has seldom been developed because of the fact that its foundation has not been properly designed for such traffic. This, coupled with careless or unscientific methods of construction, have in general placed the pavement upon a lower plane of efficiency than it deserves. Provided careful attention is paid to the details of construction, the asphalt macadam will in many cases prove not only satisfactory but economical.

Foundations.—An existing macadam or Telford makes an excellent foundation for asphalt macadam pavements, provided it is sufficiently thick and well drained to afford adequate support. Too often the thickness of the old road is overestimated. In many cases pavements have been laid on old broken-stone roads, presumably 6 inches or more in thickness, which in reality averaged but little over 2 inches



ROLLING TOPPING COURSE OF ASPHALT, RHODE ISLAND AVENUE NE., WASHINGTON, D. C., OCTOBER, 1919.

of true broken stone. Under such conditions failure of the new pavement is almost sure to follow if subjected to heavy loads when the subgrade is wet. Broken-stone foundations for ordinary traffic should seldom be less than 6 inches thick, and for heavy traffic should run from 8 to 12 inches in thickness. Deficiency in thickness should be remedied by the addition of fresh broken stone, which should be thoroughly rolled and filled with screenings to make a finished macadam. The old road should preferably be disturbed as little as possible, but when badly worn into ruts or potholes, or when it is to be materially widened, scarifying, reshaping, and bonding with water may be necessary in order to prevent irregularities from showing up in the finished pavement.

Old gravel roads may sometimes be utilized as foundations, but gravel carrying a high percentage of clay can not be depended upon to support heavy loads. Old brick, block, and concrete pavements make satisfactory foundations, provided all bad depressions are first patched with either hot or cold mix asphaltic concrete.

General features of construction.—The asphalt macadam is laid upon the prepared foundation in a single course of large size broken stone of about the same dimensions and grade as in ordinary macadam construction. A wider range in types of rock may however be allowed owing to the fact that the natural cementing value of the rock may be ignored. After rolling the layer of coarse stone, hot asphalt cement is applied in such quantity as not merely to cover the surface, but to flow into the voids between the stone fragements and thus penetrate the entire wearing course. Application of the asphalt cement may be made either with hand pouring pots or mechanical distributors as later described. After such application the surface voids are filled by spreading and rolling in a thin layer of stone chips. All surplus of stone chips and dust is then broomed off of the surface and a second application or seal coat of asphalt cement is made, covered with stone chips, and the pavement completed by rolling.

Spreading and compacting coarse broken stone.—Before laying the pavement all excess dirt and fine material should be swept from the surface of the foundation. This will not only promote a closer bond between pavement and foundation, but will tend to prevent the broken stone from becoming coated with dust and thus interfere with the adhesion of the asphalt cement to the surface of individual fragments. As the completed thickness of the pavement is usually made from 2 to 3 inches, the broken stone should all pass a 2-inch ring. It should consist of sound, durable, and angular fragments of uniform quality and should contain no dirt or other objectionable matter, occurring either free or as a coating on the stone. Wide variations in sizes, particularly running to small sizes, result in the formation of spots which are so dense that uniform penetration of the asphalt will be hindered or entirely prevented. Such spots, although not discernible in the newly finished pavement, will ravel and disintegrate under traffic long before the pavement has attained its normal life. For this reason the size of broken stone should be carefully inspected as to suitability. For this class of work specifications of the Bureau of Public Roads require a broken stone product at least 95 per cent of which will pass a 2-inch laboratory screen, and at least 85 per cent of which will be retained upon a 1-inch screen. In addition the specifications require that from 25 to 75 per cent of the product shall pass a 1½-inch screen. Except in special cases which require a different method of treatment than here considered the rock should be sufficiently hard to prevent the excessive formation of dust during initial compaction before the first application of asphalt is made. To insure this quality specifications frequently require the rock to show a French coefficient of wear of not less than 7 when subjected to the abrasion test.

The broken stone should be shoveled and not dumped in place upon the foundation. The practice of dumping loads where the stone is required and spreading or flattening out the piles not only results in segregation of fine material, thus hindering proper penetration of the asphalt at spots, but also makes it impossible to uniformly compact the wearing course. An uneven, bumpy road will therefore be the result.

After being spread uniformly over the foundation to the desired thickness, usually about 3 inches loose, the broken stone should be dry rolled until the fragments have firmly interlocked. A 10 or 12 ton three-wheel roller is usually satisfactory for this purpose and should be operated exactly as in macadam construction. The extent of rolling is a most important consideration and should be carefully watched. If the stone is not thoroughly keyed together before the asphalt cement is applied it is practically impossible to properly consolidate the pavement for heavy traffic after the asphalt has chilled or set. The result will be a wearing course, which will develop waves and ruts in the course of time. On the other hand, if the broken stone is overrolled, dust begins to accumulate on the surface of the fragments and tends to prevent proper adhesion of the asphalt. There is also danger of filling the voids with fine material produced by crushing the larger fragments under the roller and thus preventing uniform penetration of the asphalt. Extreme overrolling will moreover round the fragments and prevent interlocking. On the whole, however, there exists a general tendency to underroll and much unsatisfactory work in the past is directly responsible to this tendency. If during rolling any surface irregularities appear they should be remedied by loosening the surface and removing or adding coarse stone as may be required. Such places should, of course, be again compacted to insure uniformity.

Manipulation of the asphalt cement.—The first application of hot asphalt cement should be made as soon as possible after the coarse broken stone has been compacted. Whether application is made by hand pouring or by a mechanical distributor, there are certain important details which should be closely observed. In the first place, no asphalt should be applied unless the entire depth of coarse stone is thoroughly dry, and after a rain sufficient time should be allowed for drying out. The broken stone surface should be clean and uniform in texture and should be free from all ruts, bumps, or depressions. For this reason traffic should never be allowed upon the compacted course before the asphalt is applied, and any existing irregularities should be remedied before application. This is extremely important in spite of the fact that many surface irregularities may apparently be rolled out after application of the asphalt. Such elimination is more than apt to be but temporary. The initial bond produced by the asphalt is so great that while the stone may be squeezed into depressions it does not become thoroughly compacted at such places, and months later, under concentrated wheel loads, the position of the original ruts and depressions will appear at the surface of the pavement.

Before application the asphalt cement should be heated to a temperature between 275 and 350° F., which will render it sufficiently fluid to penetrate the wearing course before congealing, provided the weather is not cold. If heated above 350° F. for an appreciable length of time the asphalt will harden and may be otherwise injured by coking or burning. If heated lower than 275° F. proper penetration will be hindered or prevented, and an excess will remain near the surface and cause bleeding in hot weather. Application of the asphalt should not be made in cold weather, and the air temperature at time of application should preferably be not less than 65° F.

The proper normal consistency of asphalt cement will vary somewhat with climatic and traffic conditions, also with the kind of rock which is used. Because of relative ease of application in cool weather a strong tendency exists to use a softer asphalt than is altogether desirable. Such practice is apt to produce a wavy road under concentrated motor traffic. Penetration limits for asphalt cement were indicated in the table given previously.

Uniformity in rate of application of the asphalt cement and its depth of penetration into the pavement are equally important and should receive just as close attention as the proper proportioning and thorough combination of concrete. A surplus of asphalt at any point will produce a soft fat spot which will develop into a bump, while a deficiency will tend to promote disintegration and raveling once the seal coat is broken. The proper quantity of asphalt to use for first application on a compacted course 2½ inches thick is from 1.5 to 1.75 gallons per square yard. Less than 1.5 gallons will not penetrate uniformly for the entire depth and the pavement will not be thoroughly bonded. On the other hand, much in excess of 1.75 gallons will create a surplus which is apt to work to the surface in warm weather and cause bleeding or produce general waviness of the pavement under the shove of heavy traffic. Proper and uniform distribution can only be secured by the use of suitable methods.

Hand pouring.—In spite of the general impression to the contrary excellent results may be obtained by applying the asphalt with hand-pouring pots. It is necessary, however, that the pots be properly designed and that at all times the spouts be kept open for their full width. Two types of pots should be used—one with a slotted spout not less than 8 inches wide and the other with a one-half inch nozzle. In the former the slot should be horizontal so that the operator walking directly across the road may carry it in one hand and apply the asphalt for a full width of 8 inches. When pouring, the spout should be kept close to the broken stone surface and never more than 2 or 3 inches above it. The pot with small nozzle should be used only to touch up spots or narrow strips that may be occasionally missed with the wider spout. Great care should be taken that there is no overlapping, but that each strip poured makes a neat joint with the preceding strip.

It is not ordinarily advisable to pour the strips at right angles to the center line of the road, as such practice repeated with the seal coat is more apt to develop a washboardy appearance in the finished road after it has been subjected to traffic. A better method is to pour the asphalt diagonally across the road and, when seal coating, to cross the pouring lines of the first application at approximately right angles.

As an aid to uniform distribution, alternating the direction of pouring on each succeeding trip is desirable. Before pouring, the pot should be gauged, so that during application it will be emptied on one or two trips across the road. Thus a 3-gallon charge will cover a strip 8 inches wide and 25 feet long if applied at the rate of a little over 1.6 gallons per square yard. If the road is, say, 20 feet wide, the angle of application for a 3-gallon charge is ascertained by measuring off 25 feet diagonally across the road, from side to side. A constant check should be kept on distances, and until the pourer becomes experienced, a string should be stretched to guide each trip. With a little practice the pourer will soon learn to keep the rate of distribution uniform by walking somewhat faster when the pot is full than when it is nearly emptied. It is advisable to have at least two heating kettles and two pourers on the job.

Mechanical distribution.—Excellent results may be obtained with mechanical distributors provided they are properly designed and operated. Most of the modern distributors are of heavy construction and large capacity and apply the heated asphalt under pressure through a set of nozzles set in a frame close to the road surface. As the distributor passes over the course of compacted broken stone before the asphalt reaches the road it is very important that the load be so distributed that rutting will not occur. Many otherwise well-constructed roads have been seriously injured by rutting due to the use of a distributor with too narrow tires.

In operating a mechanical distributor it is very important that applications should not overlap at either the sides or ends, and that at the completion of an application the pipes and nozzles should not be allowed to drain onto the road and thus produce fat spots. All nozzles should be kept clean and free so as to avoid unnecessary touching up. For covering narrow strips that may have been missed by the distributor a narrow-spout pouring pot may be used. Rate of application is controlled by measuring off the distance that the contents of the distributor should cover in a single trip. The width of application being known. The speed of the distributor should then be adjusted so as to just cover the distance during the emptying of the tank when the feed of asphalt to the nozzles is set. Slight adjustments in feed should be made by an experienced operator when variations in speed occur during distribution.

It should be remembered that the covering capacity of a large mechanical distributor is greater than the rolling capacity of a single roller and the natural desire to use a distributor to its maximum capacity should not be allowed to handicap the construction of the road through under-rolling.

Filling surface voids.—Immediately after the first application of asphalt has been made, and progressing with it, a thin uniform layer of small-size broken stone should be spread over the surface in such quantity as to fill the surface voids. The road should then be rolled with the addition of more broken stone if necessary until the surface is tight and thoroughly bonded.

The size of broken stone used for this purpose is commonly known as three-quarter inch. Specifications of the Bureau of Public Roads require at least 95 per cent to pass a 1-inch laboratory screen, and at least 85 per cent to be retained upon a one-quarter inch screen. It should be as clean and free from dust as possible and thoroughly dry when applied, or otherwise its bond with the road will be interfered with and this will prevent proper adherence of the seal coat which is next applied. The same effect will be produced if dust or dirt are allowed to collect upon the surface of the asphalt treatment before the small stone is spread. For this reason the stone should be spread as soon after application of the asphalt as possible.

It should be broadcasted with a wide swing of the shovel in order to distribute it uniformly in a very thin layer. The use of an excessive amount is not only wasteful, but will result in caking on the surface and in the formation of an excessive amount of stone dust under the roller. After the road has been thoroughly rolled it should be carefully broomed to clean the surface and remove all fine material which is not firmly held in place by the asphalt. The road is then ready for the application of the seal coat.

Application of seal coat and cover.—The second application or seal coat of asphalt is made in exactly the same manner as described for the first application except that the quantity is less. From 0.5 to 0.75 gallon per square yard will ordinarily be required, the exact rate being dependent upon the texture of the surface treated. The surface should be uniformly coated, but an excess is to be avoided in order to prevent the formation of an unnecessarily thick mat or carpet. The same grade of asphalt should be used as in the first application.

Immediately after the asphalt is applied it should be covered with a uniform layer of small size broken stone such as used after the first application. The road should then be rolled until the surface is smooth and uniform. An excess of cover should be avoided, as it will grind up under traffic and overload the seal coat with mineral matter. Such overloading will reduce the life of the seal coat and promote disintegration. In general the amount of cover should be kept to the minimum required to blot up the excess asphalt and prevent it from sticking to the wheels of vehicles. The mat so produced should not exceed a thickness of one-half inch and should preferably be about three-eighths inch.

Asphaltic concrete.—Asphaltic concrete is composed of a mixture of mineral aggregates and asphalt cement usually prepared at a central plant and laid while still hot upon a suitable foundation. Various patented combinations and an unpatented mixture commonly known as Topeka are the types of asphaltic concrete which are most widely used. The thickness, after compaction, is customarily 2 inches, and the surface of those types constructed with a relatively coarse aggregate and showing an open texture is given a seal coat of hot asphalt cement followed by a light covering of stone chips or sand, which is forced into the surface by rolling.

Foundations.—Old gravel, macadam, Telford, cobble, stone block, brick, and cement concrete have been satisfactorily used as a foundation. Cement concrete, bituminous concrete, macadam, or crushed stone base should be used on new construction—the type to be governed by local conditions.

Should an old gravel, macadam, or Telford road be used care must be exercised to see that adequate drainage has been provided and that the thickness is such as will withstand the loads which the finished road must support. A thickness of not less than 6 inches of gravel or crushed stone, free from an admixture of earth, is advisable, and additional thickness up to 10 or 12 inches under heavy traffic and poor subsoil conditions may be necessary. Ordinarily the old gravel or macadam surface should be lightly scarified, brought to uniform grade and contour, and thoroughly rolled. To this old material should be added a course of clean crushed stone, 1 to 1½ inches in size, the thickness of which will be governed by the depth of the old material. Two inches evenly spread and bound into the old scarified surface by thorough rolling will be sufficient if the total thickness of the base so obtained is not less than the minimum mentioned above.

When old cobble, stone block, brick, or cement concrete are to be used as base, the irregularities in contour should be taken up by the addition of open mix binder, which is an asphaltic concrete from which the finer aggregate is omitted.

When a new cement concrete base is required it should, under any but exceptional conditions, be 6 inches in thickness of a 1: 3: 6 mixture. A thinner base over a very favorable subsoil has been successfully used, but there is danger of heavy trucks shattering a lighter foundation should the subsoil become so misplaced by action of water or otherwise as to require the concrete foundation to act as a beam with considerable span. A thicker base or richer mix is generally unnecessary unless the traffic is composed of exceptionally heavy units and uniform support of the subgrade can not be depended upon. The 1: 3: 6 mixture and 6-inch thickness have been very generally used throughout the Borough of Manhattan, New York City, over a long period of years and have demonstrated their suitability under any normal conditions. This is the type of base in use on Fifth Avenue and other important streets. Where water has been kept out of the subgrade the 6-inch base has carried heavy loads successfully. The top surface of the concrete base should not be smoothed but left rough, which improves the bond between base and surface mixture.

It is claimed by some engineers that a bituminous concrete or bituminous macadam foundation offers some advantages not possessed by other types such as its superior protection against underlying water, its freedom from cracking, its superior bond with the wearing surface and its shock absorbing properties. These claims, on the other hand, are dis-

CONCRETE BASE, BINDER COURSE, AND ROLLING ASPHALT TOPPING, RHODE ISLAND AVENUE NE., WASHINGTON, D. C., OCTOBER, 1919.

puted by exponents of other types of bases as possessing little or no merit.

The use of a bituminous base should be attended by greater care in the preparation of the subgrade, since with this type of base greater reliance must be placed in the supporting value of the subgrade than when a thicker macadam having greater load-distributing properties on a concrete base having slab strength, is used.

Mixtures.—Several different mixtures varying widely in proportions and nature of aggregate, all known as asphaltic or bituminous concrete, are in use, but for the purpose of this article only mixtures having a carefully and mechanically graded aggregate of broken stone sand and filler combined with asphalt cement will be considered. A mixture of this type, knownas a modified Topeka, has the following proportions specified by the Bureau of Public Roads:

The broken stone shall consist of angular fragments of rock, excluding schist, shale, and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone. It shall be that product of the crusher which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing ½-inch screen, not less than	95
Retained on ¼-inch screen, not less than	20

The sand shall be composed of sound, durable stone particles, free from a coating of clay or loam. When tested by means of laboratory screens the sand shall meet the following requirements:

	Per cent.
Passing ¼-inch screen	100
Retained on 200-mesh sieve, not less than	90

The mineral filler shall consist of limestone, dust, dolomite dust, Portland cement, or natural cement. It shall be free from foreign or other objectionable material. When tested by means of laboratory sieves, the mineral filler shall meet the following requirements:

	Per cent.
Passing 30-mesh sieve	100
Total passing 200-mesh sieve, not less than	65

The total mineral aggregate shall consist of a uniform mixture of the broken stone, sand, and mineral filler, the required grading of each being such as to produce, when properly proportioned, a mixture conforming to the following limitations for grading. The exact proportion of each constituent producing a total mineral aggregate within these limitations shall be as directed by the engineer. When tested by means of laboratory screens and sieves the total mineral aggregate shall meet the following requirements:

	Per cent.
Passing ½-inch and retained on ¼-inch screen	5 to 10
Passing ¼-inch screen and retained on 10-mesh sieve	11 to 25
Passing 10-mesh and retained on 40-mesh sieve	7 to 25
Passing 40-mesh and retained on 80-mesh sieve	11 to 36
Passing 80-mesh and retained on 200-mesh sieve	10 to 25
Passing 200-mesh sieve	5 to 11

Proper proportioning of this aggregate is secured by accurate weighing and the quantity of asphalt cement is determined in like manner.

In order to show the comparison between this and a coarse aggregate type such as bituminous concrete, proportions of the latter material as specified by the Bureau of Public Roads, are as follows:

The broken stone shall consist of angular fragments of rock, excluding schist, shale, and slate, free from thin or elongated pieces, soft or disintegrated stone, dirt, or other objectionable matter, occurring either free or as a coating on the stone. The stone shall meet the following requirements:

	Per cent.
French coefficient of wear, not less than	8
Toughness, not less than	8

That portion of the product of the crusher, which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing ½-inch screen, not less than	95
Retained on ¼-inch screen, not less than	85

That portion of the product of the crusher, which, when tested by means of laboratory screens, will meet the following requirements:

	Per cent.
Passing 1-inch screen, not less than	95
Total passing ¾-inch screen	25 to 75
Retained on ¼-inch screen, not less than	85

The sand for fine aggregate shall be composed of sound, durable stone particles, free from a coating of clay or loam. When tested by means of laboratory screens the sand shall meet the following requirements:

	Per cent.
Passing ¼-inch screen	100
Total passing 40-mesh sieve	30 to 70
Retained on 200-mesh sieve, not less than	90

The mineral filler shall consist of limestone dust, dolomite dust, Portland cement, or natural cement. It shall be free from foreign or other objectionable material. When tested by means of laboratory sieves, the mineral filler shall meet the following requirements:

	Per cent.
Passing 30-mesh sieve	100
Total passing 200-mesh sieve, not less than	65

Mixing and laying.—The mixing plant includes bucket elevator, rotary drier, an additional elevator, screen, storage bins, weighing devices, and mixer through which the aggregate passes in the order named. Heating tank and weighing device are required for the asphalt cement. Both mineral aggregate and asphalt cement are heated to temperatures varying from 200° to 300° F., depending upon the character of the asphalt cement used.

The mixing continues until all particles are thoroughly coated with bitumen and the hot mixture delivered on the road at a temperature of from 200° to 300° F. It is here dumped upon the foundation or dumping platform, at a point other than where it is to be finally spread and compacted, and is entirely rehandled by shoveling into place with hot shovels. It is then raked to uniform grade, contour, and thickness (usually about 2¾ inches before compression) and rolled with a 10 or 12 ton tandem roller. Depressions developing during rolling are brought up by additional material, and the rolling should continue until thorough compaction is secured.

Over this surface is sometimes spread a thin even flush coat of asphaltic cement at a temperature of about 200° F., to be followed by a uniform coating of hot crushed stone screenings or coarse sand. The rolling continues with a 5 to 8 ton roller until the entire mixture has cooled. The finished thickness is usually specified as not less than 2 inches, although other thicknesses have been laid with success.

No attempt has been made here to do more than outline the salient features in connection with the construction of asphaltic concrete pavements. Complete specification may be secured from a variety of sources, but those contained in the American Highway Engineers' Handbook include examples of the best standard practice.

Conditions favoring selection of asphaltic concrete.—Asphaltic concrete possesses many of the desirable qualities universally attributed to sheet asphalt pavements. The stability of the coarse aggregate types, in particular, obviates the necessity for a curb to protect the edges, and even with the finer aggregate, raveling at this point is unusual except in cases where a narrow paved surface forces a heavy traffic to constantly cross and recross such edges. Under these conditions a good asphaltic macadam shoulder will satisfactorily protect the pavement.

A new construction, asphaltic concrete, offers the advantages of a surface able to withstand heavy traffic immediately following construction. When the subgrade is suitable it ordinarily requires a relatively cheap foundation, is but slightly affected by temperature variations, is easy of repair, low in maintenance cost, and possesses a tendency to iron out rather than to roughen up under traffic. It is low in tractive resistance, low in abrasive wear on automobile and motor truck tires, and because of its smooth surface causes but little vibration in motor vehicles. This is not only a source of comfort, but reduces the maintenance expense upon such vehicles.

It is peculiarly adapted as a resurfacing material, as uniform contact can be secured with all types of old pavement surfaces. It is economical in that it utilizes to the utmost the previous investment made in the old pavement.

Sheet asphalt.—Sheet asphalt is composed of a mixture of fine mineral aggregates and asphalt cement, prepared at a central plant and laid hot upon the foundation in much the same manner as that previously described for asphaltic concrete. There is a distinct difference in the method of construction, however, inasmuch as sheet asphalt is laid in two courses, called binder and wearing

ASPHALT GRAVEL MIX ON GRAVEL BASE NEAR STERLING, MASS., ON MAIN TRUNK LINE TO CAMP DEVENS, MADE IN 1912.

course. A paint coat is sometimes substituted for the binder course, but is not suitable for heavy-traffic streets. Standard practice favors the use of 1½-inch binder and 1½-inch wearing course. No seal coat or covering of stone chips or sand is required.

Foundation.—Because it is a more expensive type and is usually subjected to more severe traffic conditions, the foundation should be more carefully selected than in the case of asphaltic concrete. A rigid cement concrete base is generally used, although water bound and bituminous macadam, old cobble stone, stone block, brick, asphalt block, and asphaltic concrete have been used with success. Although a study of each individual case, taking into consideration the character of traffic, climatic conditions, character of subsoil, drainage, and condition of old pavement will be necessary when sheet asphalt is to be used as a resurfacing material, it may be said in general that the conditions should be such as will assure the carrying of the full weight of individual units of traffic by the old pavement without displacement to even a slight degree.

A Portland cement concrete foundation of 1:3:6 proportions and 6 inches in thickness, as mentioned for asphaltic concrete, is suitable under normal conditions for sheet asphalt, and is the type almost universally used. Its surface should be left rough.

A bituminous concrete or macadam base offers the same advantages as have been noted under asphaltic concrete, but have not been used to the same extent for sheet asphalt.

Mixtures.—The mineral aggregate requires the closest study, as it is chiefly upon its proper selection, proportioning, and grading that the success of the finished pavement will depend.

The sand must be hard, clean, moderately sharp, and the grains must be of such a nature that the asphaltic cement will readily adhere to them; quartz should predominate.

In addition it must be graded within limits which have been demonstrated to give the most satisfactory results. Mr. Francis P. Smith gives the following as standard mesh compositions:

	Light traffic.	Heavy traffic.
	Per cent.	*Per cent.*
Passing 200-mesh sieve	0 to 5	0 to 5
Passing 100-mesh sieve	10 to 15	10 to 25
Passing 80-mesh sieve	6 to 15	10 to 20
Passing 50-mesh sieve	10 to 40	5 to 40
Passing 40-mesh sieve	10 to 30	5 to 30
Passing 30-mesh sieve	10 to 20	10 to 15
Passing 20-mesh sieve	10 to 15	5 to 10
Passing 10-mesh sieve	5 to 12	2 to 8
Passing 8-mesh sieve	0 to 5	None.

The total for that passing the 100 and 80 mesh sieves may be from 18 to 25 per cent for light traffic, and 25 to 40 per cent for heavy traffic.

To secure the above compositions a mixture of two or more sands will usually be required.

A filler of very fine material, usually rock dust or Portland cement, is used to fill the voids, between the sand grains and to afford a greater density of the mixture. At least two-thirds of such filler should pass a 200-mesh sieve and a material portion should be impalpable dust.

The binder course consists of asphaltic concrete with a somewhat lower percentage of bitumen than would be required in a wearing course. As usually specified it contains 5 or 6 per cent of asphalt cement, about 25 per cent of material passing a 10-mesh sieve, and 40 per cent material passing a half-inch screen. If the binder course is to have a thickness of 1½ inch, stone up to 1 inch diameter may be used.

Although sheet asphalt wearing courses whose compositions show rather wide variations have given excellent service, a mixture used upon Fifth Avenue, New York, may be taken as illustrative of good practice.

ASPHALT CEMENT.

	Per cent.
Asphalt cement	10. 8
Passing 200-mesh sieve	13. 2
Passing 100-mesh sieve	12. 0
Passing 80-mesh sieve	11. 0
Passing 50-mesh sieve	24. 0
Passing 40-mesh sieve	11. 0
Passing 30-mesh sieve	8. 0
Passing 20-mesh sieve	6. 0
Passing 10-mesh sieve	4. 0

Mixing and laying.—Binder and wearing surface mixtures are prepared at a plant closely resembling that used for asphaltic concrete. The same plant may be used for both types with few changes. The two mixtures are run alternately or as required, but more binder should not be prepared than can be covered with the wearing course during the same day.

The binder may be delivered upon the street at a somewhat lower temperature than the top course material; the former varying from 200 to 300° F. and the latter from 225 to 350° F.

The binder after being dumped is completely rehandled and shoveled into place, raked to uniform thickness and thoroughly rolled to a uniform contour and grade parallel to that of the finished pavement. The wearing course should be added as soon as compaction of the binder is completed, and the whole thoroughly rolled with a 12-ton tandem roller. After the first rolling of the wearing surface and while it is still hot a light sprinkling of Portland cement should be added.

Conditions favoring selection of sheet asphalt.—Sheet asphalt is particularly adapted to city streets and it has been the standard pavement for American cities during the last 30 years. In all of our largest cities it has carried very heavy traffic with relatively low maintenance costs, and its ease of repair and construction under difficult traffic conditions have made it especially popular. Replacement of pavement sections after street openings have been made can be carried out without leaving a weak and unsightly joint and resurfacing does not require a disturbance of the foundation nor does it involve difficulties at manhole openings and street-car tracks which have a fixed elevation flush with the pavement surface. It has low tractive resistance, causes a relatively slight abrasion to motor-vehicle tires, and is noiseless and dustless.

Asphalt block.—Asphalt blocks are made from an asphaltic concrete, compressed under hydraulic pressure and laid in a similar manner and upon a similar foundation to that required for other types of block pavements. Their dimensions are usually 5 by 12 by 2 to 3 inches.

Foundation.—The cement concrete foundation of the type mentioned for sheet asphalt and asphaltic concrete is preferable for asphalt block. Over such foundation is spread a one-half inch 1:4 mortar bed, upon which the blocks are laid while the mortar is still fresh. Still another method of construction calls for laying the blocks in a dry 1:4 mortar bed.

Mixture.—The same rules applicable to the securing of a good asphaltic concrete are equally applicable to asphalt block mixtures, with the exceptions that the coarse mineral aggregate is of smaller sizes and the asphalt cement should be low in ductility and penetration.

General.—Asphalt blocks have been widely used for city pavements and offer the advantage of requiring fewer skilled laborers on the street. They can be laid rapidly, repaired or resurfaced readily, and offer many of the qualities attributed to both sheet asphalt and block pavements.

SURFACE TREATMENTS.

Surface treatments with road oils consist in general of two methods—(1) that in which it is desired to have the material act only as a dust preventive and (2) that in which it is desired to have the material form a thin bituminous mat or carpet.

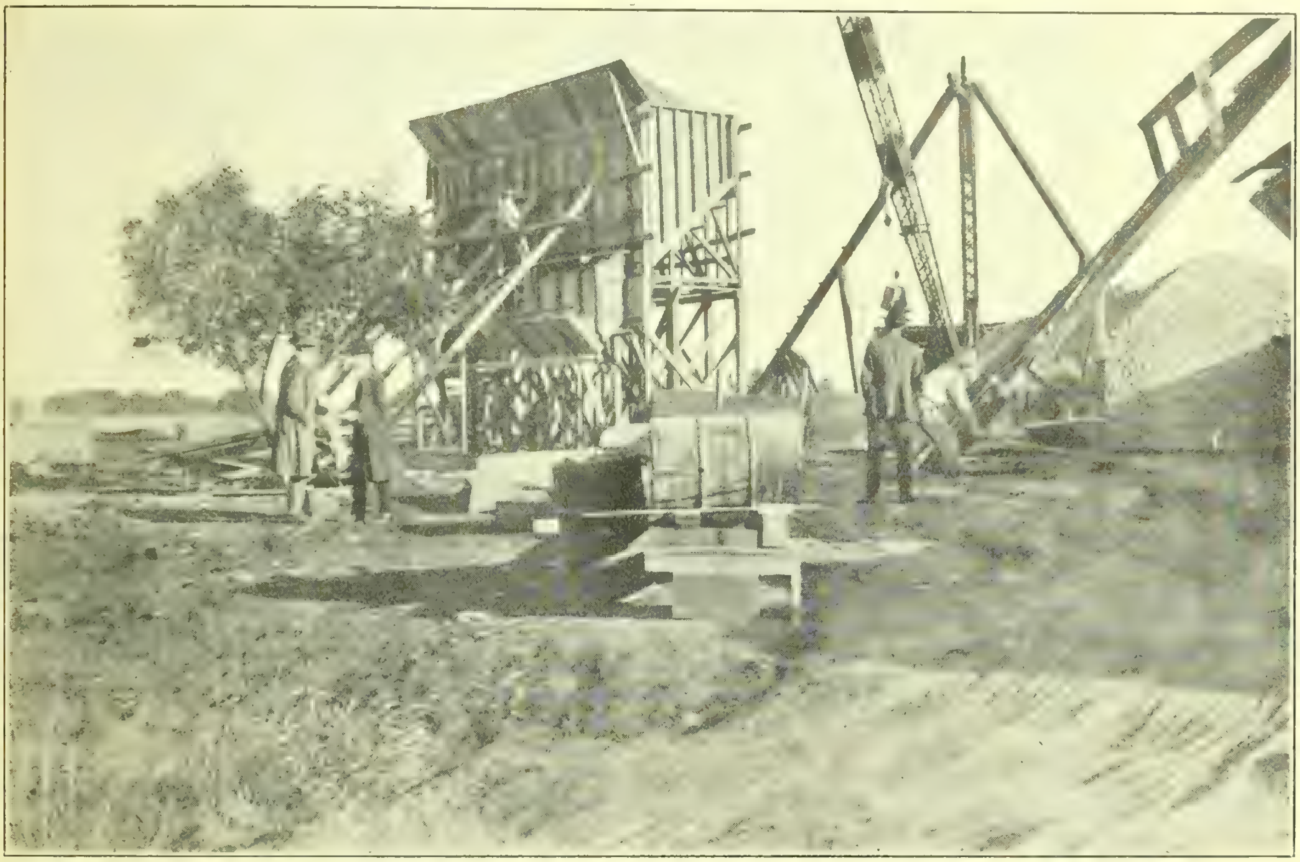
Oils for use as dust preventives are, as a rule, comparatively thin fluids which may be applied cold. To obtain the best results the road surface should be free of any great excess of dust when the application is made. The oil may be applied without heating, and the application should preferably be made by means of a pressure distributor at the rate of from one-eighth to one-fourth of a gallon per square yard. No cover of earth, sand, gravel, or stone chips should be necessary. The number of applications required to lay the dust successfully throughout an entire season will depend upon traffic and climatic conditions; one may prove sufficient, but three or four may be required.

Oils for use in surface treatment when it is desired to form a wearing mat are applied with or without heating, and are usually more viscous than are the dust preventives. For this treatment the road surface should be in a good state of repair, well consolidated, free from holes or depressions, and thoroughly swept for the removal of dust before application is made. Newly constructed roads should be permitted to consolidate under traffic before oil is applied. The oil, if heated, should be brought to a temperature of from 200° to 250° F. The initial application should be made by means of a pressure distributor at the rate of from one-third to one-half of a gallon per square yard. It should be covered with a uniform layer of stone chips or pea gravel.

ASPHALT JOINT FILLERS.

Asphalt is extensively used as a joint filler for brick pavements and asphalt or asphalt mastic. The latter, consisting of a mixture of asphalt with fine sand, is similarly used for stone block pavements. Such joint filler obviates the necessity for special expansion joints, and by permitting a certain amount of flexibility reduces any tendency of the finished pavement to crack by reason of contraction or expansion in the base. Cuts through the pavement for repairs to sewer, water mains, etc., can readily be made and the opening closed without damage to individual bricks and blocks. The asphalt carpet produced by a small excess of the filler protects the edges of brick and block from wear, reduces the noise customarily caused by these types of pavement, and reduces the slipperiness—an important consideration on grades.

SOME POINTS IN HANDLING MATERIALS.



MINNESOTA PROJECT 58. STORAGE BINS FOR SAND AND STONE AT RAILROAD STATION, WORTHINGTON. STOCK PILE AND DERRICK AND FOUR CHUTES OPERATED SIMULTANEOUSLY BY ONE MAN. BATCH MEASURING BOXES ABOVE CHUTES.

AN economical method of handling concrete aggregate was installed by Minneapolis contractors in constructing Federal-aid project No. 58, in Nobles County, Minn.

This project consists of 5.5 miles of one-course concrete pavement with proportions of 1:2:4, to be laid 18 feet wide, 7½ inches thick at the middle, and 6½ inches thick on the sides.

The project begins about 1 mile from the city limits of Worthington and is in two sections, running due west; one of 2 miles and one of 3.5 miles with a section of 6.5 miles between, which was gravel surfaced in 1918 and is not included in this project.

The road was graded 24 feet wide in 1918 by county forces, and the grading to be done in this project consisted in widening the road to 30 feet and placing 6-inch drain tile in all cuts. The soil is a heavy, yellow clay on the first section and a black soil on the second section.

The contract was let on July 14, 1919, to contractors whose bid was as follows:

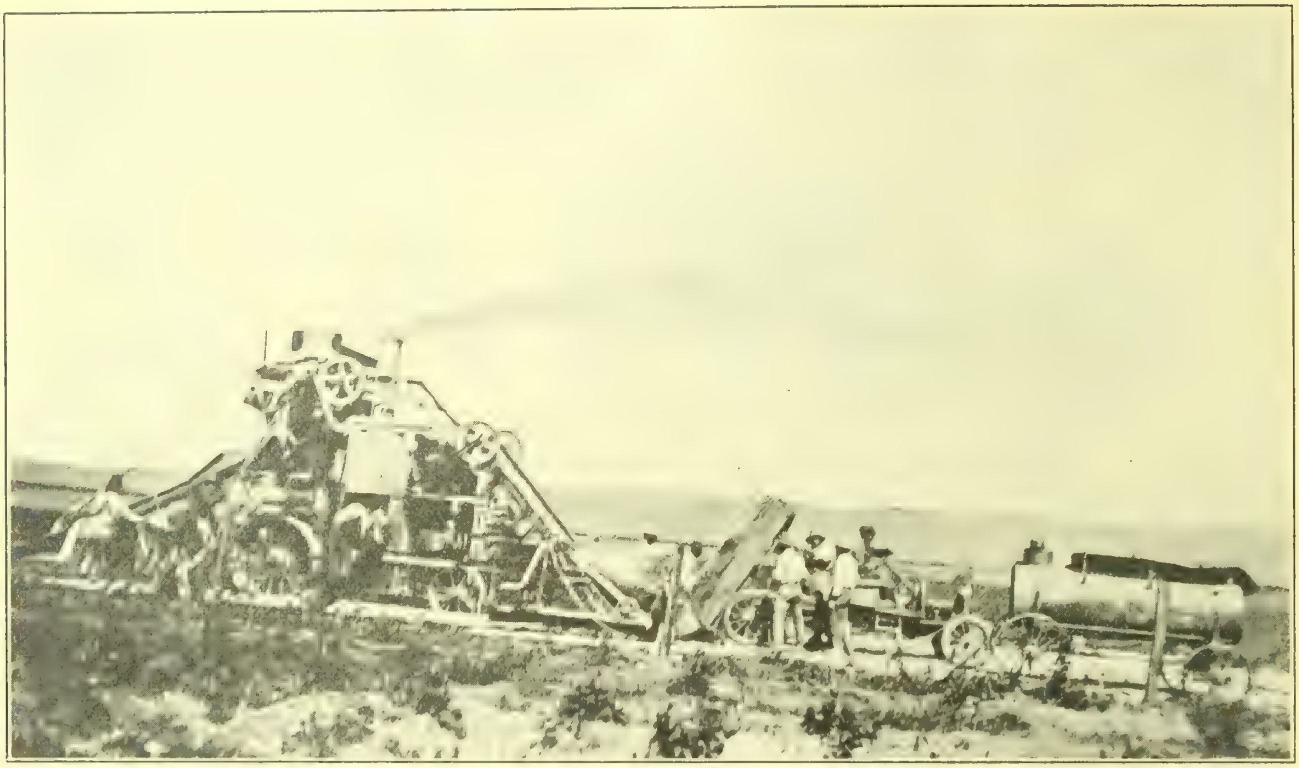
Excavation, 15,304 cubic yards, at $0.65	$9,947.60
Tile in place, 30,000 linear feet, at $0.22	6,600.00
Concrete pavement, 58,340 square yards, at $2.74	159,851.60
Total bid	176,399.20

Concreting began September 8, 1919, at Station 160 and was continued until October 24, when work was shut down for the season at Station 96 + 75, during which time 12,650 square yards were laid. Atlas cement, Mankato sand, and Jasper quartzite were brought in by train to Worthington, and water was pumped from Whiskey Creek at Station 54.

A 3-sack mixer was used with a tamper, and four 5-ton trucks hauled aggregate from the railroad at Worthington. These trucks were divided into four compartments across the truck, each with a capacity for a complete batch, and each compartment had a separate end gate which was operated by hand from the outside. The truck was backed up to the mixer skip, the body elevated, and the lower gate opened, allowing a batch to run into the skip. While the skip was being hoisted, the truck and the mixer moved forward a few feet to be ready for the next batch, and the operation was repeated until the truck was empty.

Water was pumped by a gasoline pump through a 2-inch pipe for a maximum distance of 2 miles.

At the railroad station there was erected a cement storage bin holding over a carload, with a bucket elevator operating from a boot placed at the end of the ties. The bin was divided into four compart-



MIXER IN OPERATION ON A WYOMING FEDERAL-AID PROJECT.

ments; each had a measuring box holding three sacks, located just above a steel chute which discharged into the truck. One man operated all four chutes simultaneously.

Bulk cement was delivered to the cement bin and was unloaded into the elevator boot by one man using a wide scoop running on two small wheels. This method of handling cement caused a good deal of trouble, as the cement arched over the opening into the chute, and was later discarded for a platform built on a level with the car floor and reaching to the truck roadway. Four men, each with a steel wheelbarrow holding three sacks of cement, loaded from the car and wheeled and dumped them simultaneously into the compartments of the truck alongside.

About 100 feet beyond the cement bin there was a combined sand and stone bin; the stone storage being double the capacity of the sand storage. Between this bin and the siding (see photograph) there was a crane with a clamshell bucket which unloaded sand and stone from cars on the siding into the bins or on to the stock pile.

Each bin had four measuring boxes above four steel chutes, which were discharged simultaneously by one man. After the truck had received cement in each compartment, it drew alongside the sand bin and received sand into each compartment; and then a few feet beyond stone was dumped into the compartments.

There were 30 men employed in the different operations from the arrival of the material on the cars to the finished pavement.

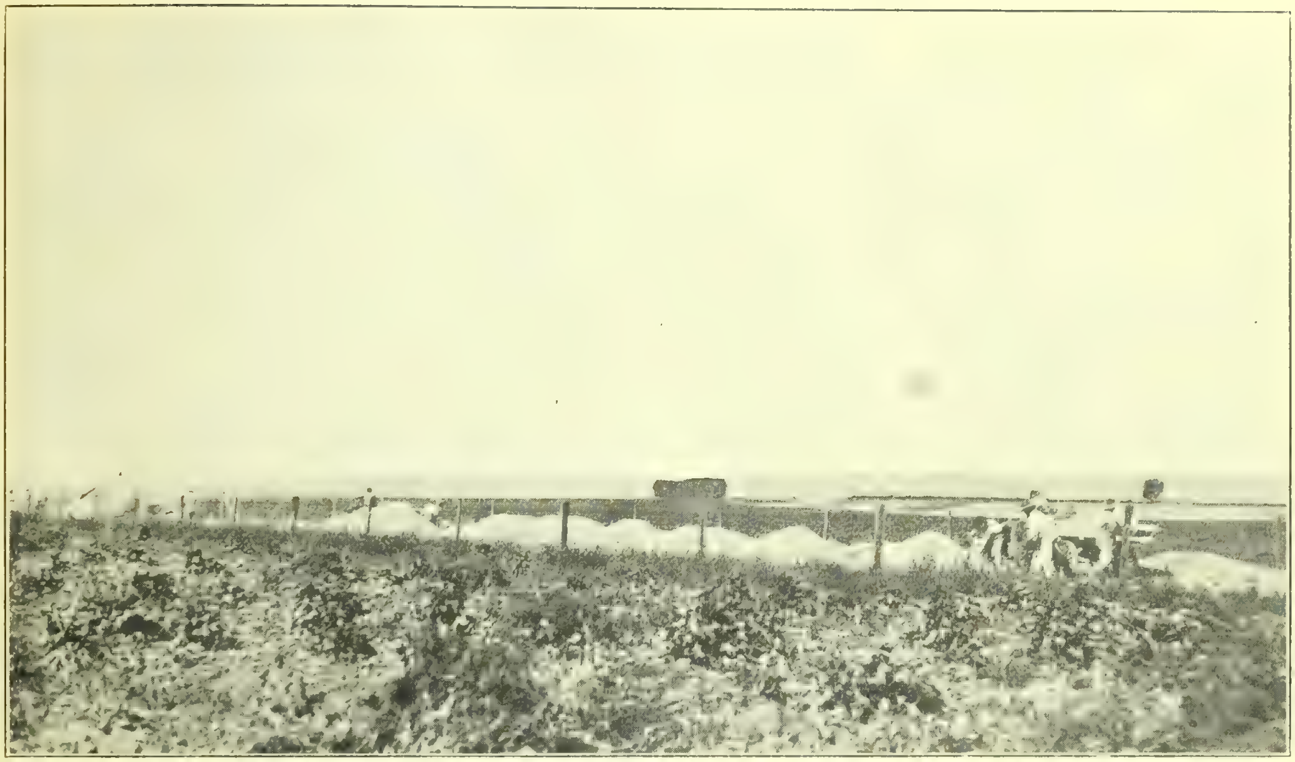
At loading plant.—One foreman, 1 mechanic, 2 men at sand and stone bin, 4 men at cement bin, 2 men with crane clamshell, 4 drivers for 5-ton trucks.

At road.—One foreman, 2 mixer operators, 3 men at chute and spreading concrete, 2 men placing side forms, 2 men on steel reinforcement, etc., 2 men on mechanical tamper, 4 men covering finished pavement, watering and removing forms.

The entire time occupied in loading from the time the truck stopped at the cement bin until it started from the stone bin was four and one-half minutes.

The following notes relative to a new method of handling materials which has been developed on Wyoming Federal-aid project No. 20 also may be of interest to those who are engaged in concrete highway construction.

The material from the gravel pit is hauled out to the road in large trucks and deposited in stock piles. Experience has, however, developed the fact that the movement of material over the prepared subgrade is a matter of considerable importance, as the use of heavy units for this purpose is certain to destroy the subgrade and to cause a considerable expenditure for the reshaping of the subgrade. Moreover, if materials are dumped in small piles on the subgrade there is the ever present possibility



STOCK PILES, SHOWING LABORERS LOADING A TRUCK, ON A FEDERAL-AID PROJECT IN WYOMING.

that a percentage of the earthy materials of which the subgrade is usually composed may find their way into the batch.

These two considerations have led the contractor on this project to adopt the system of dumping his materials at the end of the road in a large stock pile, and, for the purpose of moving them to the mixer, he has provided six Ford trucks with light bodies, which, when loaded with the materials for a single batch, can be dumped by hand. The bodies on these trucks are divided into compartments which will accommodate a four-sack batch of material. After being loaded at the stock piles a truck is driven to the mixer and the charge dumped directly into the hopper.

As can be seen at a glance, the cost of loading the truck, even from material piles placed on the ground, is no greater than the cost of loading wheelbarrows would be. The cost of operation and the wear on the trucks is said to be no greater than the constant reshaping of the subgrade where the aggregate is delivered on the subgrade by heavy trucks or by wagons. In short, the scheme is working satisfactorily on this project and with every appearance of reasonable economy.

For somewhat greater economy in operation it would be entirely feasible to build loading bins and to drive the trucks onto an elevated platform, permitting them to discharge into hoppers which could in turn be discharged into the light delivery trucks. By proceeding in this fashion a considerable amount of labor could be eliminated but the cost of the plant would be somewhat increased. The system most advisable for any individual project will, of course, depend on the length of the project and the amount of material to be handled.

AUTOMOBILE LICENSE FEES.

Up to October 18 the number of pneumatic-tired machines registered in Pennsylvania was over 435,000 for the year 1919, and the license fees received had passed the $5,000,000 mark. It is expected that the fees for the year will be about $5,100,000. In 1918 the State received in fees $4,048,185.50 from 678,786 registrations, of which 363,001 were pneumatic-tired machines.

COUNTY MATERIAL PLANT.

Maricopa County, Ariz., has a road program of 278 miles. The county supervisors and highway commissioners have decided to install a material plant with a capacity of 2,000 tons a day. It is estimated that this will save the county $3,000 a mile in rock, sand, and gravel alone in the construction of the highways, or a total saving of $834,000.

CALL FOR BIDS.

Fresno County, Calif., supervisors have called for bids on the first six units of the highway system for which the county has been bonded for $4,800,000, and which will cost $5,500,000. The bids will be on 1-2-4 and 1-3-6 concrete mix.

MATERIAL MUST BE MOVED EARLY.

WHEN seeds of information sown in a campaign of education fall upon the minds so fertile and receptive as those of the people of our Nation, the result is astounding. The hearty, liberal, country-wide response to the call for money to construct a network of highways adequate to meet the demands and requirements of the marvelous growth of traffic has been more than astounding. Inspired by the passage of the first Federal aid road act by which the Government appropriated $75,000,000 to enter into copartnership with the State and stimulated by the further appropriation of $200,000,000, the States, one after the other, and the counties of the States have provided for vast sums to further the doctrine of good roads until now there is $633,000,000 immediately available for construction in 1920.

GREATEST IN HISTORY.

And in contemplating these figures it must be remembered that in no year in the history of road building has as much as one-fourth of this sum been expended upon new highways. But that the States will go far toward exceeding the expenditures of any previous year and constructing a greater mileage than ever before is forecast by the fact that several have already laid out programs that call for the building of more than a thousand miles within their respective boundaries. The people ask for these roads and are willing to pay for them. Illinois, with a population of approximately 6,000,000, has authorized a bond issue of $60,000,000 (about $10 per capita), and a little county in Arkansas (Phillips), with a population of less than 50,000, has pledged itself for $3,734,000 for good roads. That is about $75 per head, and with the money they propose to put 117 miles of road in places where there were hardly any before.

It is estimated that last year $138,000,000 was expended in new construction. To put into construction the great sum available presents a tremendous task to the highway builders of the country. One factor will determine the degree of success with which this task may be accomplished. That is the movement of material. Without material there can be no roads. Without open-top cars there can be no material. There must be a complete utilization of the open-top cars for the movement of material at the time and all the time that such cars are available. Reports of the Railroad Administration show that in the earlier months of the year there are many thousands of open-top cars standing idle. But in 1919, when the road-building season was well advanced, there was general complaint that no cars were available for the movement of material. The supply, always inadequate, was being used for the transportation of other products.

MESSAGE TO STATE AUTHORITIES.

Recently Thomas H. MacDonald, the chief of the Bureau of Public Roads, in a letter to the State highway departments, in which he points out that the only possible relief is to use the present transportation and materials production agencies in the most efficient manner possible, said:

"It is a matter in which the State highway departments may take a large measure of satisfaction that road building is the one big public activity which got under way early in 1919, which opened a large field for unemployed labor, which offered a market for construction materials, and which has continued to increase in volume as the months have passed. It is too early to have definite figures available for this year's production of roads and total expenditures, but it is estimated that the expenditures during 1919 for hard surfaced highways, exclusive of sand-clay and similar types, will total approximately $138,000,000. The largest previous year's total expenditures for like purposes, that of 1916, was $136,000,000.

But the test of the road building organizations is ahead. The estimated summary of the funds which will be available for highway work during 1920 for the construction of surfaced highways is as follows:

Brought forward from unfinished work 1919 contracts	$165,000,000
Funds available from State and county taxes and Federal aid	273,000,000
One-fifth State and county bond issues not before available	50,000,000
One-third of the unexpended balance of State and county bond issues previously available	45,000,000
Available from new bond issues to be voted on the fall of 1919 and spring of 1920	100,000,000
Total	633,000,000

PROGRAM IS TREMENDOUS.

"This large total is more than four times the amount of money that has been expended during any previous year for like purposes. To accomplish the physical undertaking of putting into actual road construction this sum or anywhere near this sum is tremendous. It is so much greater than any program that has heretofore been attempted that a great increase in the principal factors controlling the actual production of highways is absolutely essential. These principal factors are material supplies, shipping facilities, labor supply and contractors' organization.

"The acute deficiency of open-top cars demands that our first attention be directed toward increasing shipping facilities for road materials. These facilities may be increased by two methods—first, by the more efficient use of open-top car equipment, and second, by a large increase in the supply of new cars. During frequent conferences with the Railroad Administration it has become apparent that a more efficient use may be made of the present open-top car equipment by starting the shipping season earlier than has been the general practice in the past. It has been customary to wait until contractors' organizations were ready to begin work before starting the shipment of materials. Under these conditions many thousands of open-top cars lie idle during the latter part of February, all of March, and the earlier part of April. In the spring of 1919 the number of open top cars that were idle totaled more than 250,000. As the season advanced and road contracts were actually under way, the car shortage manifacted itself here and there almost continuously, but at three different times complaints received at this office were general.

FACTORS THAT AFFECT MOVEMENT.

"We must recognize that if a strike threatens the railroads, road material will not be moved because it is not perishable. If the movement of coal demands the cars, there will be a shortage of cars for the movement of road materials. The importance of the movement of road materials must be impressed upon the public and the railroads, and for the present the road builders must correlate their calls for service so far as possible with the situation which exists—that at any critical moment when shipping facilities are involved road materials will be the first to suffer.

"Therefore, everything possible must be done to facilitate transportation of road materials under these handicaps. Railroad transportation has become too important a factor in the amount of work that can be accomplished to allow it longer to be regarded as incidental. It has become the biggest item in road production. Contracts should be awarded as early as possible that the contractors may know the amount of materials they will require at different points and they should be encouraged to place their orders for the materials requiring rail transportation as long in advance of the time they will be actually required as possible. The placing of materials in storage piles involves some expense, but this expense is small in comparison to the loss occasioned by lack of materials when the contractors' organization is waiting.

CONTRACTS SHOULD BE AWARDED EARLY.

"From the experience this year and in view of the greatly increased program for next year, it seems apparent that contracts which are not awarded during the winter months will have little opportunity of being supplied with materials which require rail hauling. Again, contracts should be awarded early and contractors should be encouraged to place their orders so that the material producers will operate their plants during all seasonable weather. In the past too many contracts have been held until later in the year, and material supplies have not been started moving during the period when the car supply is at its maximum. Also, contract prices have usually been lower for work awarded early in the season, and the State Departments and the Federal Bureau must recognize and respond to the public confidence which has been shown by the appropriations of large sums for highway improvement, by adopting every method that will help to secure the lowest prices and the most efficient expenditure of these funds.

"In view of the greatly enlarged program of road construction and the large amount of unfinished contracts which will have to go over because of lack of road materials, it would seem unnecessary to further accent the need for taking advantage of the supply of open-top car equipment in February, March, and April.

THE ONLY POSSIBLE RELIEF.

"It is apparent that many contractors who have not before been so engaged are looking to the highway field, and that the contractors' organizations will be expanded. The labor shortage may in part be met by improved machinery and equipment, but the transportation and the supply of materials can not be so readily or quickly expanded to take care of the greatly increased needs. Unless a forward looking policy recognizing these conditions is adopted at once, it is not apparent that a greatly increased production of roads will be possible next year over the miles constructed this year, yet the public is demanding of road building organizations a greatly increased production.

"Every official in an administrative capacity in the road building organizations knows that it is common for the public to demand great activity and immediate production of roads as soon as bonds have been voted. The fact that more than four times as much money is available for roads next year than has been true heretofore means that these demands will become intensified, and it will be a difficult task to impress upon the public the fact that the production of roads is controlled by factors largely outside of the control of the highway officials.

"The only possible relief is to use the present transportation and materials production agencies in the most efficient manner possible, and at the same time bend our efforts to obtain an increased car supply and an increased production of road materials. But these policies, to be effective, must be adopted by the State Departments and the Federal Bureau individually and collectively, at once, and the first step is to place under contract during December and January as great a mileage of roads as possible. In doing this the bureau wishes to cooperate with and aid the States in every way possible."

ILLINOIS DEVISES A PLAN.

The highway department of the State of Illinois has devised a plan which it hopes will result in the shipment and storage in the early part of the season of a large portion of the material the State will require in the construction of the 1,000 miles of highway called for by the 1920 plans. To supply the necessary material for this program will mean a severe tax upon the material producers unless the construction season be extended. In order to bring this about and thus assist in relieving the open-top-car situation, as well as a possible shortage of materials, the State has decided to pay for such materials as sand, gravel, and stone as delivered, without waiting for the same to be incorporated into the work. Vouchers will be issued direct to the railroad company for the freight and to the sand, gravel, and stone producers for these materials. The same will be charged against the contractor and the amount thus paid will go to reduce estimates due the contractor as such materials are used.

This arrangement will apply not only to contracts now uncompleted, but also to the contracts to be awarded in 1920. In order to make this effective on existing contracts, a supplemental agreement will be made with the contractor and the surety company. This supplemental agreement will be forwarded to the contractor for his signature with the request that he procure the signature of the surety company at an early date.

Only the hearty cooperation of all the forces engaged in the building of our roads and the utilization to the fullest extent of equipment and producing power will bring in 1920 a result in road building accomplishment such as the public has a right to expect.

NEBRASKA ROAD BUILDING.

The road building situation in Nebraska under Federal aid is reviewed in the October issue of the Monthly Bulletin of the State department of public works. Under the original Federal-aid act Nebraska was entitled to $1,600,000 from the National Government. By the amendment to the last post-office appropriation bill this amount was increased to $5,866,303.82. The Nebraska Legislature of 1917 accepted the provisions of the Federal-aid law, appropriated $640,000 for road construction under it, and authorized the State board of irrigation, highways, and drainage to lay out a system of roads for the approval of the Secretary of Agriculture.

The legislature of 1919 abolished the State board of irrigation, highways, and drainage, and created a State department of public works, and appropriated $3,093,262 for Federal-aid roads, bringing the total appropriation to date up to $3,733,262, leaving a balance of $2,133,041.82 to be taken care of by the legislature in 1921.

As laid out the State highway system includes approximately 4,500 miles of road located so that every county seat and every important town is connected. Up to October 1 project statements for the construction of 2,240 miles of this system had been submitted to the Secretary of Agriculture. Seven hundred miles of work had been placed under contract, for an aggregate cost of about $2,500,000, and it is estimated that 500 miles will be completed before the close of the present season. Surveys have been made this year on about 1,500 miles additional, and it is expected that the balance will be in shape, so that the work can be placed under contract before April 1, 1920. Before the close of the season 212 miles more of work will be placed under contract, of which 17 miles are brick paving in Douglas County, 6 concrete in Dodge, and 1 concrete in Butler. All the rest is either plain earth or graveled surface.

HERE'S A NEW ONE.

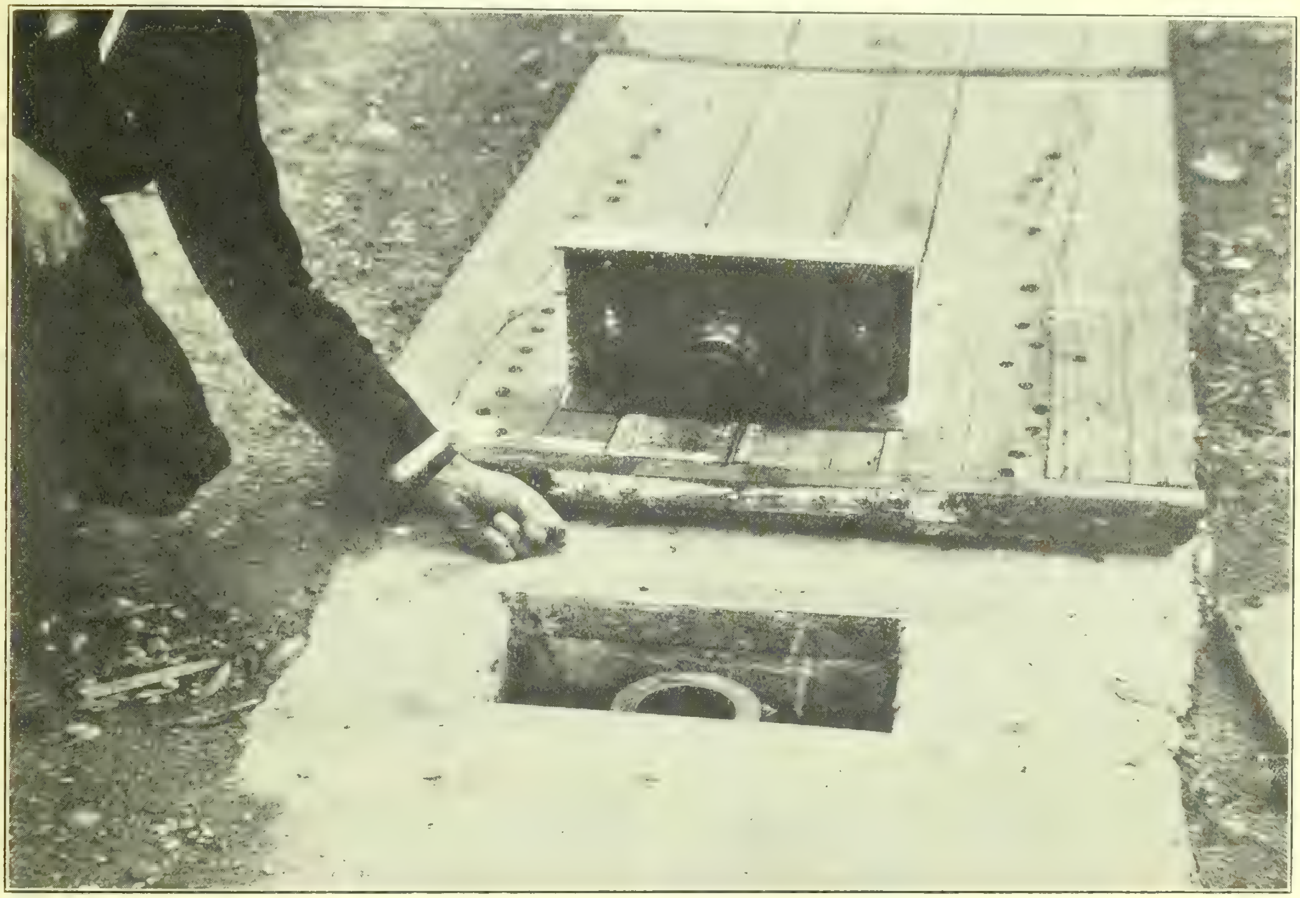
An interesting side light is thrown on the problems which highway engineers sometimes have to solve by the following comment recently found in the report of one of the engineers inspecting a Federal-aid project in New Mexico: "Relative progress is only fair due to the fact that operations have been greatly handicapped for want of water. As this is a very hot and dry season of the year, the cattle take nearly all the supply. The road construction is, therefore, greatly handicapped." We have heard of a good many difficulties which engineers have encountered in constructing concrete roads, but this is the first time that we ever heard of construction being delayed because the cattle had made away with the water supply.

WISCONSIN CONSTRUCTION.

It has been estimated that Wisconsin in 1919 will expend about $12,600,000 on highways. Of this amount $7,600,000 will be for State trunk and State-aid construction and maintenance, with the rest for township roads. The construction on the State trunk highway system will cost about $3,600,000 and that on State-aid roads about $2,000,000. Maintenance will cost about $2,000,000. A total of 146.99 miles of concrete roads is included in this program.

THE PRESENT STATUS OF IMPACT TESTS ON ROADWAY SURFACES.

By A. T. GOLDBECK, Engineer of Tests, Bureau of Public Roads.



CLOSE-UP VIEW OF IMPACT MEASURING DEVICE.

IT has been estimated that the funds available for highway construction in this country during 1920 total $633,000,000, and this is more than four times the amount expended in any other previous year. It is likely that the future will show even higher figures than these and that road construction will be pushed as rapidly as road-material resources, equipment, hauling facilities, and labor will permit. In the face of such an enormous program it behooves us to build wisely lest we be extravagant either by too much or by too little initial expenditure for our various road systems.

Unfortunately, the necessity for such vast expenditures comes almost simultanelusly with a new class of traffic which exerts a different kind of destructive effect on roads than has been exerted by traffic in the past. The heavy motor truck has transformed the road problem from one whose solution in days gone by depended upon precedent into an exceedingly important problem of design. We must be able to design our future roads to carry known maximum loads under known conditions of subgrade and weather, just as we are now able to design our bridge structures. We must not be satisfied with a constant cross section irrespective of subgrade conditions, but we must change the design of the road as nearly as practicable with changing conditions of subgrade. At the same time we must better subgrade conditions by more careful drainage. Recognizing these facts, and with the rational design of road surfaces as a goal, the Bureau of Public Roads has begun experiments to find out something of the fundamentals affecting road design.

Just as in the design of a bridge structure, the design of a road requires not only a knowledge of the materials in the structure and their behavior under stress, but it also requires a knowledge of the forces acting on the structure tending to deform it out of shape. Obviously, then, one of the fundamental problems is to determine just what forces are being exerted on roads tending to destroy them.

IMPACT ACTION ON SMOOTH SURFACE.

Anyone who has stood on a hard-road surface during the passage of a heavy truck has noticed the vibration set up in the pavement, indicating that the truck is exerting more or less of an impact action even though the surface be comparatively smooth. Such action, of course, is much accentuated after the surface becomes worn in spots or wavy, and the impact then becomes very noticeable. Heavy loads at rest on road surfaces exert but little effect except on surfaces which, for some reason, are too soft to bear the load. Actual tests have been made on a concrete road to gain some idea of the fiber stress in the concrete directly under a heavy wheel load of a loaded truck.[1] The indications are that when a wheel load of 8,500 pounds is at rest

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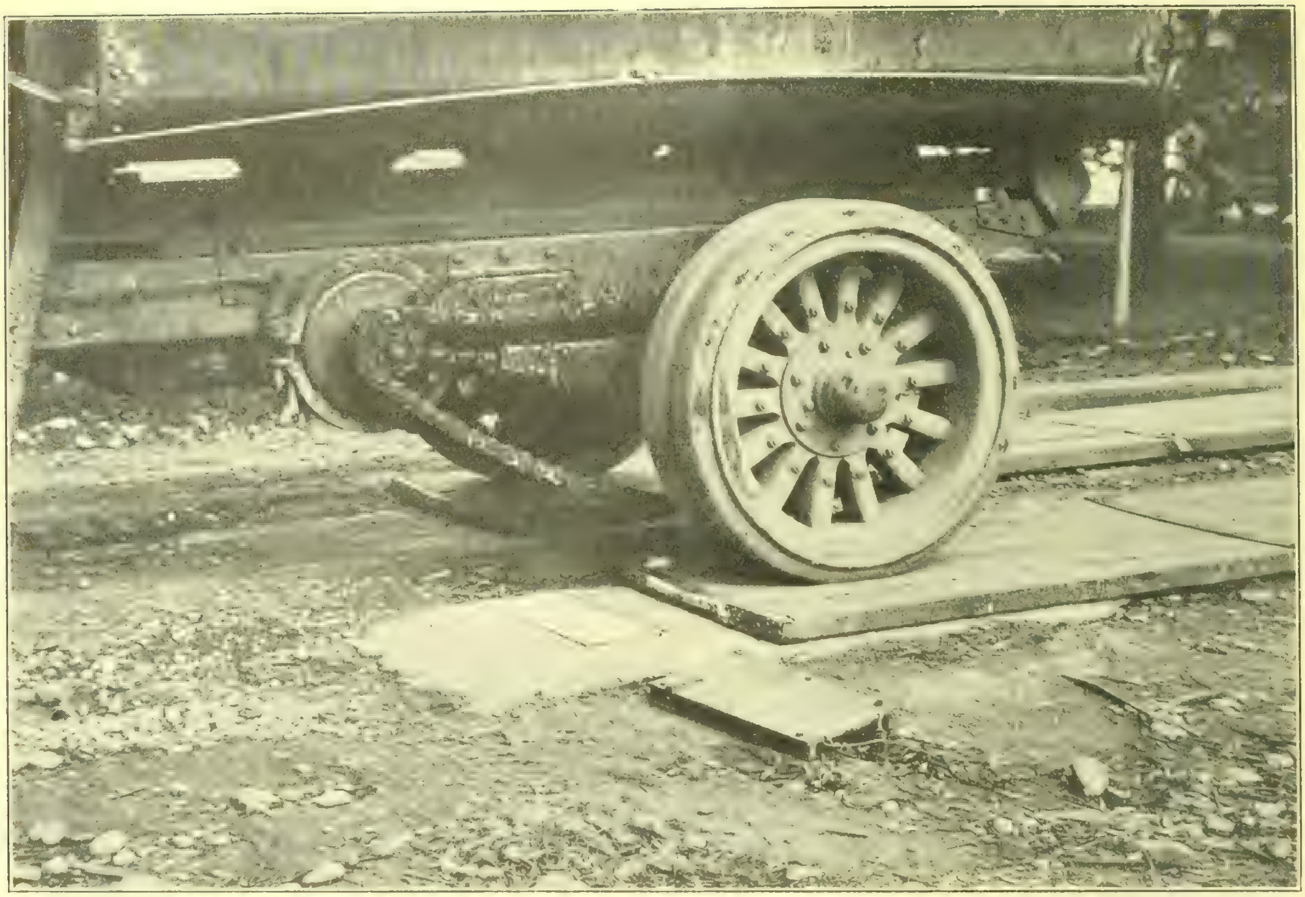
[1] Thickness of concrete slabs, by A. T. Goldbeck, Public Roads, April 1919.



VIEW OF TOP OF JACK FOR MEASURING IMPACT OF TRUCKS.

on an 8-inch concrete slab laid on a rather wet clay subgrade the fiber stress in tension is only about 34 pounds per square inch directly under the load, and since the modulus of rupture of the ordinary concrete road mixture is well over 400 pounds per square inch, and possibly as high as 600 pounds per square inch, the danger of serious cracking of the concrete under static loads is practically nil except at the corners of the slabs.

We must turn to impact then for an explanation of some of the past failures of road surfaces under motor truck traffic. How great can these impacts be as compared with the static weight of trucks? What impacts are likely to be exerted on road surfaces depending upon their degree of smoothness, and what effect have these impacts on different kinds and thicknesses of surface when laid on different subgrades? These are some of the questions we must answer before we can hope to design a road rationally.

The impact tests now being conducted by the Bureau of Public Roads aim to determine—

(1) The amount of impact delivered to road surfaces.

(2) The effect of this impact on different types of surface.

MEASUREMENT OF IMPACT DELIVERED TO ROAD SURFACES.

The method now being used for measuring the amount of impact delivered by trucks has been described elsewhere.[1] In brief, it consists of delivering the impact of a moving truck to a small copper cylinder, the blow deforming the cylinder a definite amount, depending on the intensity. In these experiments a concrete pit has been constructed in the road surface and a hydraulic jack has been placed in this pit. The plunger of the jack is enlarged at the top with a platform of suitable size for receiving the blow of one wheel of the truck. The copper cylinder which measures the blow is placed under the plunger of the jack and the blow is transmitted through the plunger to the copper cylinder. The cylinders used are turned from one-half inch copper rod and are one-half inch in length. A large number of these cylinders are prepared and are given a special heat treatment to make them uniform in their physical characteristics. A number of them are selected from each lot prepared and are subjected to pressure in a testing machine, and the deformation of the cylinder is noted for each load applied. In this way it is possible to check up the uniformity of the lot of cylinders and also to determine how much load is required to deform them to a definite length. The impact deforming the copper cylinder is stated in terms of the static load required to deform it to the same length.

A little thought will show that there are a number of different ways in which impact can be delivered to a road by a motor truck, and the test has been arranged to approximate these different conditions. For instance, the truck while in motion is caused to fall through definite heights striking the plunger of the jack. Again, the truck is made to strike obstructions of different heights placed directly on the plunger of the jack and, as described later, several other variations of impact have been investigated.

The speed of the truck has been made one of the variables in these investigations in order to permit of determining something of the law of the effect of

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[1] Preliminary Report of Impact Tests of Autotrucks on Roads, by E. B. Smith and J. T. Pauls, Public Roads, July, 1918.

GENERAL VIEW OF SLABS TO BE TESTED UNDER IMPACT.

speed of impact. Different sizes and makes of trucks loaded with different loads are being used. Thus far the tests have been confined to solid-tired vehicles, but it is the aim to extend them to an investigation of pneumatic tires and to special types of cushioned wheels and special tires. The impact of the rear of the truck only has been investigated, as this impact is greater than that of the front wheels.

RESULTS OBTAINED.

In this discussion no attempt will be made to treat of all the results obtained, but, rather, the essential features of the data will be pointed out. A number of curves are given, and these have been selected from a large number of test results because they, in general, show the maximum impacts that have been measured. In the tests here recorded a class B 3 to 5 ton standard Army truck, a 5½-ton truck, and a 1½-ton truck have been used. All of these trucks were supplied by the Motor Transport Corps of the War Department.

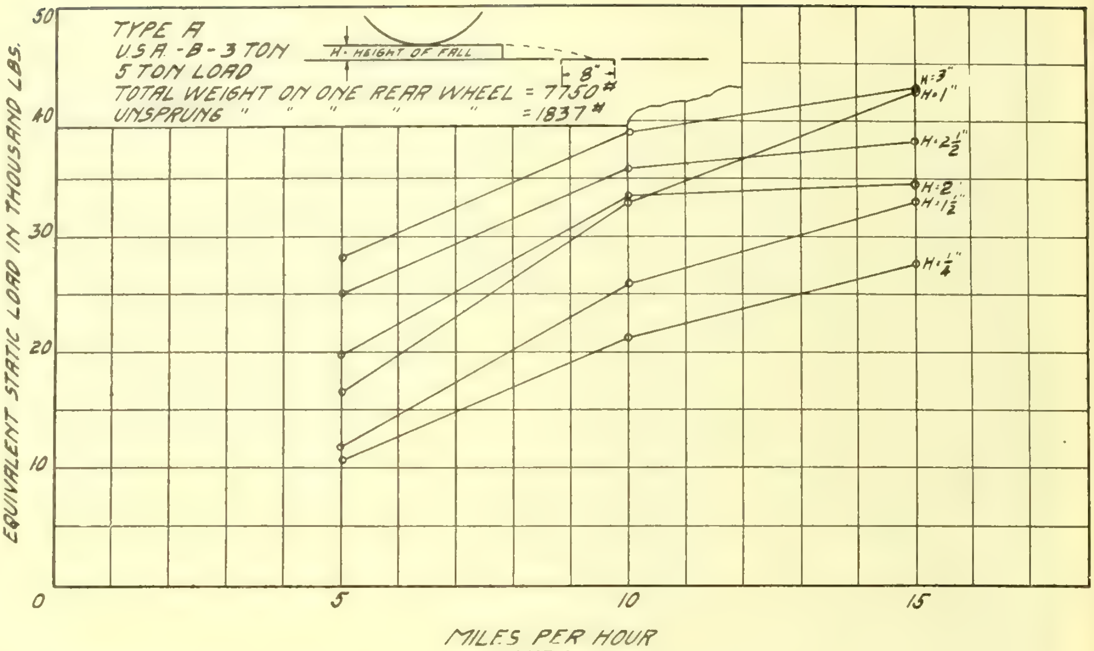
CLASS B THREE TO FIVE TONS STANDARD ARMY TRUCK

Referring to curve 1, which shows the results obtained with the class B truck loaded with 5 tons of sand and having a total weight of 7,750 pounds on one rear wheel and an unsprung weight of 1,837 pounds on one rear wheel, it should be noted that in general the higher the fall the greater is the amount of impact produced. The maximum impact pressure, when the truck was running 15 miles per hour and fell through a height of 3 inches, was 42,000 pounds, and this was 5.4 times the static load pressure exerted by the rear wheel. When the rear wheel dropped through a height of only one-fourth inch at 15 miles per hour, the impact pressure produced was 28,000 pounds, or 3.6 times the static load pressure. It will be well to note here that the unsprung weight of this truck is very heavy, and it will be seen, as pointed out later on, that this has the effect of producing high impact pressures.

In curve 2 the same truck loaded in the same manner as above was used, but the rear wheel of the truck was caused to strike an obstruction which was placed on the plunger of the measuring jack. It will be noted that this condition of impact is very much less severe than shown in curve 1 described above. In general, the impact pressure seems to increase with the velocity and also with the height of the obstruction.

In obtaining the results shown on curve 3, wedge-shaped blocks were mounted on the plunger of the jack, the angle of inclination of the blocks being varied for the several tests. The rear wheel of the truck simply rolled over these wedge-shaped blocks and produced pressure on the copper cylinder as shown in the curve. As would be expected, the pressure produced increases with the angle of inclination of the block and also increases with the speed. This condition of pressure is realized in the road surface when a truck rolls into a depression and the wheels strike the far side of the depression, and these tests show that the steeper the far side of the depression the greater will be the pressure produced on the road.

Should the depression be deep enough and the speed of the truck sufficient, the wheels will leave the surface of the road, jumping over the depression and landing on the far wide with considerable impact. This condition was tested by placing wedge shaped blocks on top of the jack as in the previous test, elevat-



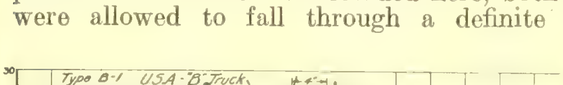
CURVE 1.

ing the point of jump off and running the truck at a speed such that it fell on the center of the wedge-shaped block, giving pressures as shown in curve 4. The height of fall in each of these cases was 2 inches. It will be seen that this gives a very severe condition of impact. These tests were very difficult to make, as it necessitated very careful driving to make the rear wheel land directly on the center of the jack. A large number of runs had to be made before results of any value at all could be obtained.

FIVE AND ONE-HALF TON TRUCK.

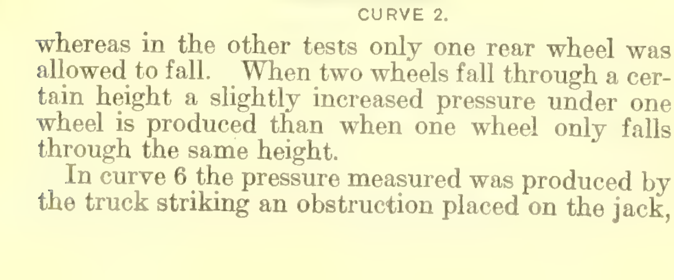
In curve 5 results are shown obtained with a 5½ ton truck carrying a load of 5.65 tons, having a total weight of 8,060 pounds on one rear wheel and an unsprung weight of 1,000 pounds on one rear wheel.

NO 1 ORIGINAL, 0.5" DIA. 0.501" LONG
NO.2 DEFORMATION = 28.3% = 12,250 LBS. STATIC LOAD
NO.3 " = 48.9% = 21,500 " " "
NO.4 " = 66.9% = 40,000 " " "



DEFORMATION OF COPPER CYLINDERS.

The tests shown in this curve were obtained by running the truck at different speeds and allowing it to fall through different heights. It will be noted in general that the pressure increases with the speed and to some extent with the height of fall. In the particular set of results recorded here, both wheels were allowed to fall through a definite height, whereas in the other tests only one rear wheel was allowed to fall. When two wheels fall through a certain height a slightly increased pressure under one wheel is produced than when one wheel only falls through the same height.

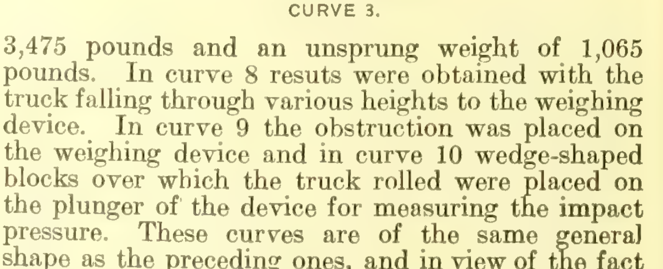


CURVE 2.

In curve 6 the pressure measured was produced by the truck striking an obstruction placed on the jack, and this pressure is much less than in the previous case, as shown in curve 5. The same general tendency for pressures to increase with the speed and with the height of the obstruction is shown just as in the case of the class B Army truck.

In curve 7 are shown the results obtained when the truck rolled over wedge-shaped blocks placed directly on the jack. The same general shape of curves was obtained as in the case of class B truck, the intensity being somewhat less in this case.

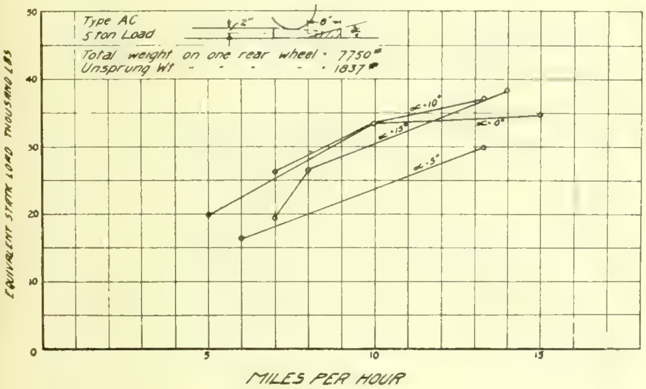
Curves 8, 9, and 10 show the impact pressures produced with a 1½-ton truck carrying a load of 3,660 pounds having a total weight on one rear wheel of 3,475 pounds and an unsprung weight of 1,065 pounds. In curve 8 resuts were obtained with the truck falling through various heights to the weighing device. In curve 9 the obstruction was placed on the weighing device and in curve 10 wedge-shaped blocks over which the truck rolled were placed on the plunger of the device for measuring the impact pressure. These curves are of the same general shape as the preceding ones, and in view of the fact that this truck was lighter, the pressures obtained were less than previously described.



CURVE 3.

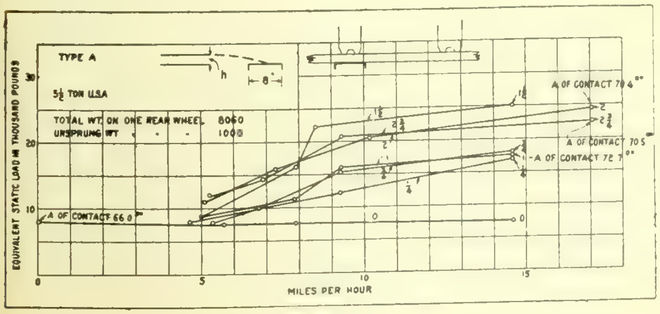
GENERAL DISCUSSION OF IMPACT PRESSURE TESTS.

It is seen from the preceding test results that under certain conditions the impact pressure produced by heavy motor trucks is very large, the highest pressure thus far measured being in the neighborhood of 42,000 pounds when the weight on the rear wheel causing this pressure was only 7,750 pounds. It was pointed out that the unsprung weight on one rear wheel of this truck was 1,837 pounds. In the case of the 5½-ton truck which has an unsprung weight of 1,000 pounds, it has been shown that the impact pressures produced were very much smaller than in the case of the class B Army truck. Considering a specific case, when the class B Army truck, whose total weight of 7,750 pounds on one rear wheel, unsprung weight 1,837 pounds on one rear wheel, fell through a height of 2 inches at a speed of 15 miles per hour, the impact pressure produced was about 34,500 pounds. In the case of the 5½-ton truck loaded with a load of 8,060 pounds on one wheel, with an unsprung weight of 1,000 pounds on one rear wheel, and under corresponding conditions of speed and height of fall, the impact pressure produced was only 23,500 pounds, or only 68 per cent of the impact pressure of the Army truck. The unsprung weight of the 5½-ton truck was only 56 per cent of that of the Army truck, whereas the gross load carried on the rear wheel was slightly larger in the case of the class B truck. The indications are, therefore, that a light unsprung weight tends to lessen the impact of a truck on the road surface.

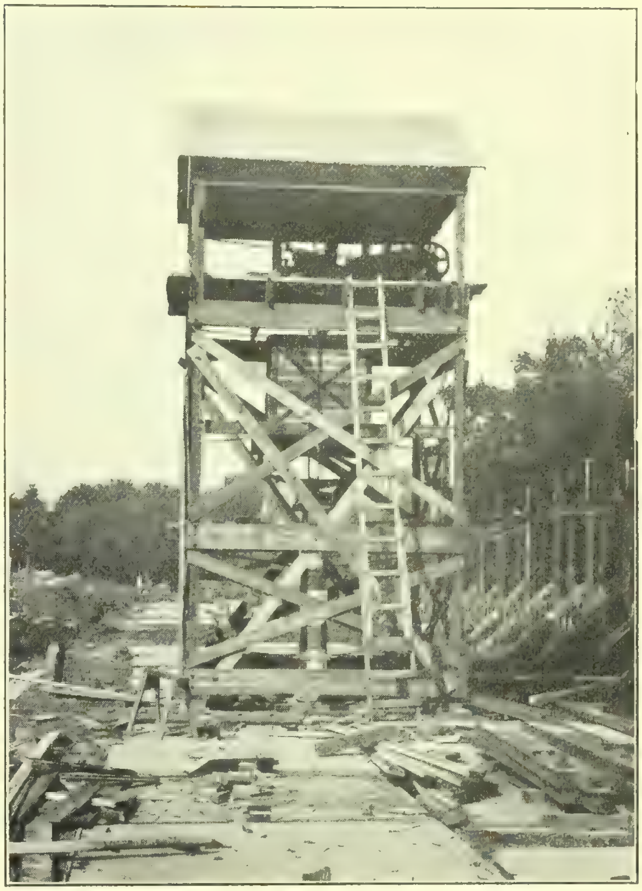


CURVE 4.

Referring to curve 9, giving results for a 1½-ton truck having a total weight of 3,470 pounds on one rear wheel and 1,065 pounds unsprung weight on one rear wheel, the impact pressure at a speed of 15 miles per hour and with a height of fall of 2 inches, was in the vicinity of 14,000 pounds per square inch. It will be noted that the unsprung weight of this truck is practically the same as that of the 5½-ton truck and the impact pressure produced is very much lower than in the case of the 5½-ton truck, so that it can not be said that unsprung weight alone influences the impact pressure produced on the road, but the sprung weight also exerts some influence on this pressure.



CURVE 5.



VIEW OF IMPACT MACHINE FOR TESTING ROAD SLABS.

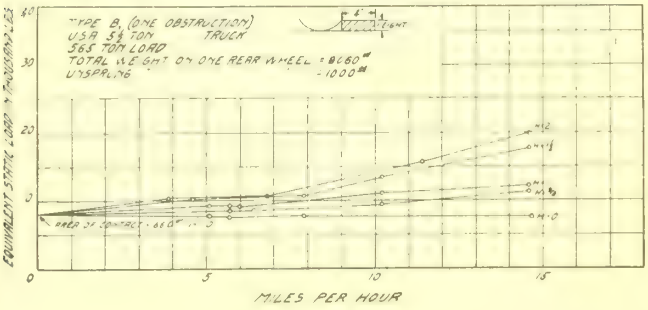
GROSS LOAD NOT ONLY FACTOR.

These facts are very significant, for they show that the gross load of a truck is not the only factor which influences the pressure of the wheels of the truck on the road surface. It is possible to have vastly different impact pressures exerted on the road by two different trucks both having the same gross weight but having different distribution of their sprung and their unsprung weights, and when questions of road design are to be considered the actual wheel pressure on the road is the all-important thing rather than the gross load of the truck. Would it not seem logical to take these facts into consideration in framing legislation dealing with the restriction of maximum sizes of motor trucks on roads, and moreover, do these facts not open the way toward a more equitable system of license fees than the more or less arbitrary systems based on gross load, carrying capacity, or horsepower now in use?

The effect of the speed of trucks on the amount of impact produced on road surfaces is indicated by these tests. It has been stated that the impact of vehicles on roads varies as the square of the speed, but the present tests indicates that within practical speed limits this is not the case. In the results obtained thus far the impact on the road varies with some power of the speed, this power, however, being less than two and extending down as low as one. The present data do not warrant a close analysis to determine this relation.

SPRING DEFLECTION A FACTOR.

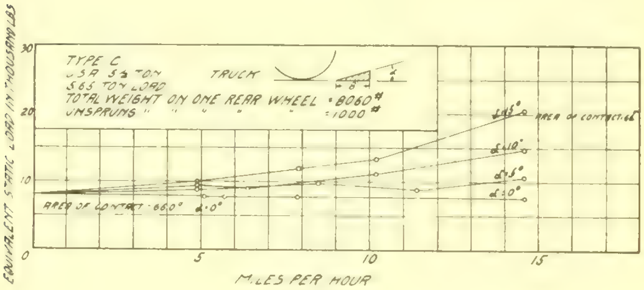
At first thought it would seem that the impact should vary directly as the height of the fall when a truck rolls off an obstruction and falls on a road surface, but these tests indicate that this is not true, the reason being that the action of the springs of the vehicle give the unsprung weight an acceleration above that due to gravity and, depending upon the spring action and upon the amount of sprung and unsprung weight, the impact effects with various heights of fall are likely to vary with different trucks.



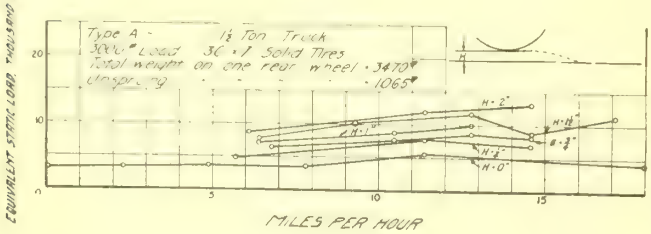
CURVE 6.

The amount of spring deflection at the instant the impact occurs is another factor influencing the amount of impact on the road.

Having determined the amount of impact exerted on surfaces by trucks under these artificial conditions, the next question arises as to what impacts are actually produced on road surfaces of different degrees of roughness. Undoubtedly the road having a rough surface will be subjected to greater impact than the smooth road, and information of this character has as yet not been obtained, but it is hoped that it will be possible to obtain these results within the coming year by means of special equipment now being constructed.

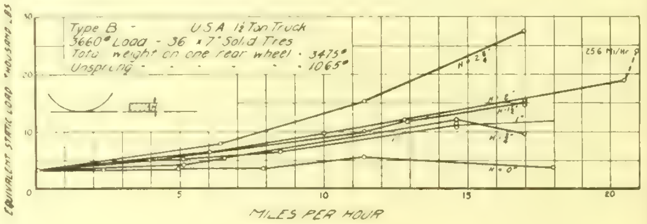


CURVE 7.



CURVE 8.

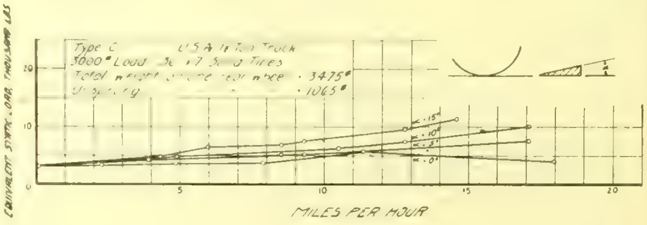
What use shall be made of the results of the impact tests in the design of road surfaces? The theory for the design of beams under static loads states that the strength of the beam varies as the square of the depth, and in one instance use has been made of this theory to place road surfaces of different kinds on an equal basis so far as their load-carrying capacity is concerned. On the other hand, it may be shown theoretically that when loads are applied with impact on beams their strength varies directly as their depth and not as the square of the depth. With rubber-tired vehicles it is a question as to whether the impact produced is of a suddenness requiring design by the latter theory, and it would seem to be reasonable that in view of the cushion effect of rubber tires the load-carrying capacity of the slab will vary as some function intermediate between D and D^2. When the proper theory to use is determined, knowledge of the amount of load applied by impacts will permit of actually designing roads to properly sustain these loads.



CURVE 9.

DETERMINATION OF THE EFFECT OF IMPACTS ON ROAD SURFACES.

Having obtained the amount of impact exerted by trucks, the next question is that of the damaging effect of impacts on road surfaces. We are attempting to gain some information on this point through a series of tests now under way. We have constructed a number of slabs 7 feet square laid directly on the subgrade. Half of these sections are laid on a subgrade which is purposely kept wet and half of them are on a well-drained subgrade. The sections thus far constructed include concrete in depths varying from 2 inches to 10 inches and brick constructed on varying thicknesses of concrete base. Various kinds of brick have been used, including repressed, wire-cut lug and vertical fiber brick. We have used monolithic, semimonolithic and sand cushion construction; both Portland cement grout and bituminous mastic fillers have been used. One section is laid on a bituminous mastic cushion with a bituminous mastic filler. In other sections the brick have been laid directly on a subgrade and in still others on a prepared macadam base. We are testing these slabs by means of an impact machine which is designed to represent the conditions existing on the rear wheel of a truck. This machine has an unsprung weight of 3,000 pounds and will carry a sprung weight of 9,000 pounds. These weights correspond approximately to those that would exist on the rear wheel of a 7½-ton truck. The lower end of the sprung weight is shoed with a solid rubber tire and the whole weight will be raised to a height such that when allowed to fall, the impact delivered will be one that might be delivered by a 7½-ton truck. The observations will consist of noting the behavior of the surface under repeated impacts of this machine and will also include measurements of



CURVE 10.

(Continued on page 25.)

GROWTH OF FEDERAL AID WORK.

By A. C. BRUCE, Office Engineer, Bureau of Public Roads.

THE growth of the Federal aid post road work carried on under the supervision of the Bureau of Public Roads is graphically shown by the progress curves herewith presented. These curves show the status of work from month to month since the passage of the act in July 1916, to the latest monthly statement dated October 31, 1919. There are many stages of the work not shown, but the four principal stages outlined in the act are covered, namely, project statements approved by the Secretary; plans, specifications and estimates recommended for approval by the Chief Engineer; project agreements executed by the Secretary; and vouchers passed for payment by the auditor.

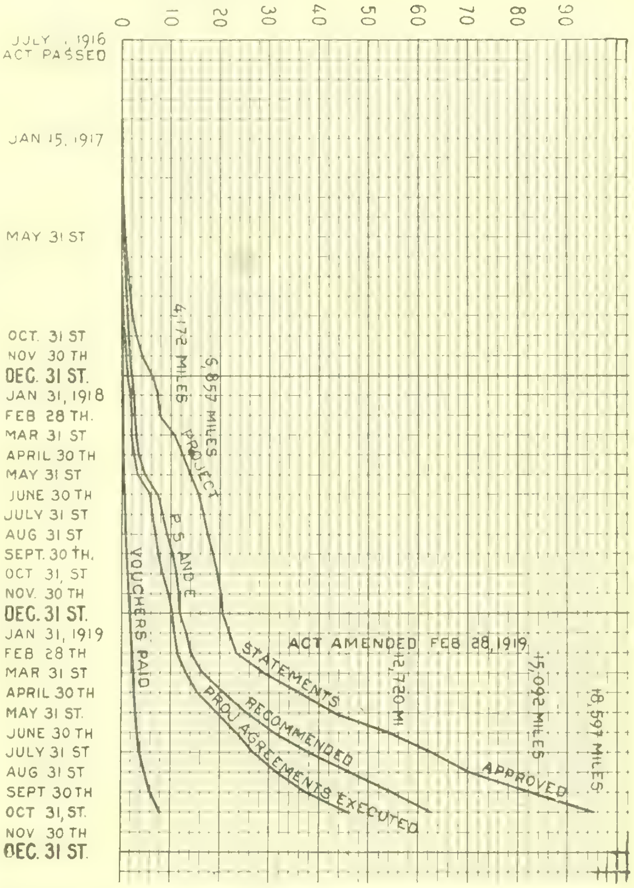
It will be seen that a very noticeable impetus was given to all stages of the work by the passage of the amendment to the act, February 28, 1919, whereby an appropriation of $200,000,000 was added to the original $75,000,000.

The actual value of work completed to date on Federal aid projects is considerably in excess of that shown by the curve "Vouchers paid." This is due to the fact that there is a lag of from one to four months between the completion of work and the presentation of the vouchers. There are also some projects which require that Federal aid payments shall be made only upon completion of the entire project. There is every indication that this season's completed work will call for Federal-aid payments of at least $25,000,000.

On October 31, 1919, there were 1,929 project statements approved by the Secretary. These represented a total of 18,597 miles and were estimated to cost $225,159,801, of which amount Federal aid was requested to the amount of $95,498,139.65. If the curve can be assumed to indicate the probable future progress of the work, it would be expected that the total $275,000,000 Federal aid would be covered by approved project statements about December 31, 1921.

Plans, specifications and estimates have been recommended for approval by the chief engineer for 1,373 projects. These projects represent 10,373 miles of road with a total cost of $145,777,433, of which Federal aid has been recommended for $62,745,137. The approved plans for the above roads show practically all the usual types of construction, and the estimates show a range in cost per mile from $2,500 to $100,000.

At the same rate of progress as that shown on the curve for the past six months, sufficient plans would be recommended by the chief engineer by October 31, 1921, to take up the entire $275,000,000.



(Continued from page 24.)

deflection of the surface. Nothing can be said of the results at the present as the tests have not progressed to that extent. We aim to continue these investigations with bituminous surfaces laid on concrete bases using a 1 : 3 : 6 as well as a 1 : 1½ : 3 base. In addition, broken stone bases will be used under the bituminous surfaces.

With the completion of these tests it is hoped that sufficient data will have been accumulated to place the design of roads on a much sounder basis than at present and it is hoped that the results combined with the results of still other investigations will finally lead to a suitable method for determining with certainty on road types and cross-sections for definite subgrade and load conditions. In conclusion, the writer wishes to give due acknowledgement for the work of E. B. Smith and J. T. Pauls who are conducting these impact tests in detail.

VOTE ROADS BONDS.

Three districts of Kanawha County, W. Va., have voted a total of $1,459,000 in bonds for the improvement of highways. The districts are Cabin Creek, $904,000 of bonds, Elk, $395,000, and Union, $160,000.

NEARLY $25,000,000 ALLOWED IN FEDERAL AID IN TWO MONTHS.

IN September and October Federal-aid allowance to roads in the projects approved by the Secretary of Agriculture called for $24,780,906.43, or about one-fourth of the total amount of Federal-aid money apportioned to the States under the Federal-aid act and the amendment to the last post-office appropriation law for the present fiscal year. In the two months agreements signed by the Secretary and modifications to previous agreements the Federal-aid allowance amounted to $14,046,541.73. The cost of the roads in the statements approved is estimated at $52,722,392.10 and that in the project agreements signed at $32,284,579.31.

Up to the close of office hours October 31 last, 1,927, project statements, representing 18,596.788 miles of highway, had been approved, while the Secretary of Agriculture had signed 1,065 project statements, representing 8,407.293 miles of road. The total amount of Federal aid allowed in the statements approved amounted to $95,498,140.85 and in the agreements executed to $46,107,333.38. The highways included in these projects are estimated to cost $225,267,847.25 in the statements approved and $107,549,468.74 in the agreements signed by the Secretary.

SEPTEMBER A BANNER MONTH.

The Bureau of Public Roads considered more Federal-aid projects in September than in any previous month. The record shows 165 project statements approved, 8 revised statements approved, and 2 withdrawals, while 98 project agreements and 23 modifications of previous agreements were signed by the Secretary of Agriculture. The statements approved were for 1,606.62 miles of road, estimated to cost $27,645,241.91, with Federal aid amounting to $12,703,746.24. The agreements signed were for 625 miles of road, estimated to cost $13,056,082.22 and a Federal-aid allowance of $5,680,742.89.

In the number of statements approved Minnesota led with 16, while there were 2 revisions from that State. New Hampshire and West Virginia each had 15 projects approved, Nebraska coming next with 11. The Nebraska mileage was 217.367, mostly for earth, gravel, and sand-clay roads, that of Minnesota 161.25, West Virginia 81.11, and New Hampshire's only 13.436, an average of less than a mile to a project.

The Nebraska mileage was the greatest included in the projects approved during the month from any one State. Indiana had the second largest, 185.8, that of Minnesota came third, followed by Montana with 106.5 miles and New Mexico with 95.5. The Indiana roads are all to be of asphalt, brick, or concrete, while the Minnesota and West Virginia projects include a considerable mileage of hard-surface construction. The Montana and New Mexico roads are to be mostly earth or gravel.

In five States the statements approved show estimated cost of roads in excess of $1,000,000, and in three States the Federal aid allowed is more than $1,000,000. The five States together had 34 statements and 4 revisions approved, with an estimated cost of the roads $15,184,871.51, or 54.7 per cent of the total for all the States. The Federal aid allowed for these statements amounts to $6,986,322.94, more than one-half the total for the month. In each of five other States the roads will have an estimated cost of over $900,000.

Indiana not only led all the other States in the estimated cost of the roads embraced in the statements and in the amount of the Federal-aid allowance, but the aggregate for that State was by far the greatest for both cost and Federal aid for one month since the passage of the law. The totals of the only four projects approved for that State are estimated cost $7,128,013.20 and Federal-aid allowance $3,537,330.80.

LARGEST PROJECT TO DATE.

One of the four Indiana projects breaks the record for estimated cost and for Federal-aid allowance. It is for 114.4 miles of road running from Evansville north through Vanderburgh, Warrick, Spencer, Dubois, Orange and Lawrence counties estimated to cost $4,223,076 and will be given Federal aid to the amount of $2,111,538. Another Indiana project, for 56.7 miles in Lake, Porter, and Laporte Counties, of the same construction, will cost $2,292,351, with an allowance of $1,134,000. This is the third largest project, in estimated cost, in the records.

Kansas follows Indiana in September's record. Her five projects approved have an aggregate cost of $3,498,754.59 for 87.28 miles of road and will receive $1,309,200 Federal aid. The largest Kansas project is for 44.5 miles of concrete road in Sumner County, estimated to cost $1,622,808, with an allowance of $667,500. Unlike the Indiana projects, this is all in one county and is to date the largest project on record for a single county. A second Kansas project, for 25.07 miles of asphalt, brick, or concrete road in Dickinson County, will cost $1,119,648.47, according to the estimate, and will receive Federal aid to the amount of $376,050.

BIG PROJECTS IN ILLINOIS.

Illinois had two new projects and a revised project approved, for an aggregate mileage of 50.83, an estimated cost of $1,995,711.40 and Federal aid of $1,043,090.70. The revised project was for additional mileage of 10.7, added estimated cost of $837,001.80 and Federal aid of $463,735.90, for a bituminous macadam or concrete road in Kankakee and Iroquois Counties. This revision gives this project, Illinois No. 2, a total length of 65.2 miles, an estimated cost of $1,741,701.80, and an allowance of $870,850.90, making it the fourth largest project approved in the history of Federal aid up to September 30, 1919.

Sixteen new and two revised projects in Minnesota, aggregating 161.25 miles in length, are estimated to cost $1,436,385.64 and will receive an allowance of $673,997.68. Texas is the fifth State whose project approvals for the month exceed $1,000,000. Seven new and one revised project in that State, 87.491 miles long, will cost $1,126,006.68 and receive Federal aid amounting to $422,703.

California will receive $475,688.95 Federal aid on four projects estimated to cost $951,377.90; Maryland $456,464 of Federal aid for five new and one revised project to cost $948,879.25, and West Virginia $438,689.10 Federal aid for 15 projects estimated to cost $912,124.90.

HIGH COST OF ROADS PER MILE.

The 2.01 miles of concrete or brick road in Cuyahoga County, Ohio, project No. 84, estimated to cost $190,011, is the highest costing project approved in September. It is at the rate of $94,532.83 a mile. This is probably the highest cost per mile of any project approved to date. In a recent issue the cost of a short project in Massachusetts, 0.578 mile long, was stated to be at the rate of $127,864 a mile. This was a mistake, as included in the project was a concrete bridge at the estimated cost of $49,758, bringing down the cost per mile of the road to a much smaller amount.

New Jersey's only project approved during the month is a concrete road which is estimated to cost at the rate of $85,404.34 a mile. A short road in Grand Forks County, N. Dak., less than a mile in length, will cost at the rate of $65,904.17 a mile. In Kanawha County, W. Va., 2.6 miles of concrete road are estimated to cost $53,302.19 a mile. In her 5 projects approved Kansas has the high average of $40,086.55 a mile for 87.28 miles of road.

In the project agreements for September, Pennsylvania led all the States, with 22 agreements signed by the Secretary of Agriculture for a total of 114.586 miles of road, estimated to cost $5,534,619.60, and a Federal-aid allowance of $2,324,927.72. Washington was second in the record, with 12 original and 3 modified agreements, for 77.47 miles of road, estimated to cost $1,602,431.80, for which the Federal aid will be $745,039.69.

APPROVALS AND AGREEMENTS IN OCTOBER.

October was another big month in the consideration of Federal-aid projects, and the figures for both statements approved and agreements executed made records. Statements approved numbered 185, and there was 1 revised statement in which the allowance of Federal aid and the estimated cost of the road was increased. This is the largest number of statements so far approved in a single month. The mileage of the roads involved showed an increase of 232 miles over the large September mileage. There was a decrease, however, from the previous month in the estimated cost of the roads and in the total amount of Federal aid called for in the approved projects.

In project agreements signed by the Secretary of Agriculture there was a big increase over the September figures, making the October record far ahead of that of any previous month. The Federal-aid allowance on these agreements was at the rate of $100,000,000 a year. The Federal-aid allowance in the projects approved during the month was at the rate of $145,000,000 a year. Of the agreements executed all represented approvals made in previous months.

The figures for October were: Project statements approved, 185; revised, 1; withdrawn, 3; mileage of projects, 1,848.098; estimated cost of roads, $25,502,372.28; Federal aid allowed $12,077,150.19. Project agreements signed, 138; modifications of previous agreements, 20; mileage, 888.948; estimated cost, $19,227,497.09; Federal aid allowed, $8,365,798.92.

IOWA FIRST IN MONTH'S RECORD.

In the statements approved the estimated cost of roads in eight States is greater than $1,000,000, while two States will receive Federal aid amounting to more than that amount. Several States which have not heretofore taken high rank in the monthly record of approved statements came to the front in October.

Iowa is the banner State for the month, being first in total mileage involved in the approvals, in the estimated cost of the roads and in the Federal aid allowed. She was third in the number of projects approved, 14. The total mileage of the roads in these 14 projects is 216.81, no other State's approvals representing as much as 200 miles. The estimated cost of the roads is $3,978,847.95 and the Federal-aid allowance $1,951,750.

North Carolina with an estimated cost of $2,182,381.36, an allowance of $1,091,190.66, for 18 roads having a mileage of 135.61, stood next to Iowa in the amount of Federal aid and the cost of the roads, and second in number of projects and fourth in mileage.

Tennessee was third in estimated cost and Federal aid allowed, the figures being, respectively, $1,849,-

780.39 and $924,890.17, for 6 projects having a mileage of 97.69. Georgia had 23 statements approved, 8 more than North Carolina, the second State in the number of projects. They were for 147.05 miles, next to the largest mileage of the month. The estimated cost of the roads is $1,779,729.56, the fourth on the list. Michigan, Oregon, Missouri, and Texas are other States represented by approved statements aggregating more than $1,000,000.

In the cost of the roads in the agreements executed Ohio led all the other States, with an estimated cost of $2,543,483.80, for which there will be a Federal-aid allowance of $1,119,000. Illinois was second in the estimated cost of her project agreements, $2,877,565.18, and first in the amount of Federal aid, $1,431,900.74. Indiana came third in the cost of the projects and second in Federal-aid allowance, the figures being $2,294,383.23 and $1,125,000. Washington and Georgia are other States in which the estimated cost of the roads in the agreements exceeded $1,000,000.

MICHIGAN'S LARGE PROJECT.

Michigan, with only two project statements approved in October, holds the distinction of presenting the largest one for month, while her second project is also one of the big ones approved. The largest project was her No. 35, for 25.559 miles of brick, concrete, or bituminous road in Jackson and Washtenaw Counties between Jackson and Ann Arbor, estimated to cost $1,018,050, for which the Federal-aid allowance is $509,025. The other Michigan project is estimated to cost $627,110 and will receive an allowance of $287,850. It is for 14.211 miles of road in Wayne County, between Dearborn and Flat Rock, known as the Telegraph Road, and will be built of brick, concrete, or bituminous.

Iowa had three large projects approved, their aggregate cost being estimated at $2,543,483.80, for which there is Federal aid amounting to $1,234,600. Two of these projects are parts of the North Iowa Pike. The largest is that part of the pike in Hancock County between the Cerro Gordo County line and Kossuth—24.9 miles of brick or concrete road, estimated to cost $953,350.20, with an allowance of $476,600. That part of the pike in O'Brien County, between Sheldon and the Clay County line, also to be of brick or concrete, 22.59 miles long, will cost $832,436 and receive $416,000 Federal aid. The third of the big Iowa projects, 17.1 miles of brick or concrete, is in Black Hawk County, part of the Hawkeye Highway, between Waterloo and Cedar Falls, with a cost of $757,697.60 and Federal aid of $342,000.

A large Tennessee project has an estimated cost of $721,134.47 and is given an allowance of $360,567.23. It is 48.876 miles long, is to be macadam, and is a part of the Bristol-Memphis Highway, between Tate Springs and Kingsport, in Grainger, Hawkins, and Sullivan Counties. The cost of this macadam road will average over $14,750 a mile. It runs through east Tennessee mountainous and hilly country. Among the other Tennessee projects is No. 16, for a bridge 0.237 mile long, over the Cumberland River near Clarksville, in Montgomery County, which will cost $176,543.

Maryland project No. 37, 19 miles of concrete road between Ingleside and Lamber, in Queen Anne and Kent Counties, will cost $660,000. Arizona and Oregon are represented in the projects, which will cost between $500,000 and $600,000; an Oklahoma project will cost $399,300; and projects in Mississippi and North Carolina are estimated to cost about $342,000 each.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama.	12	Lowndes	2.50			Oct. 24	$16,861.80	$8,430.90
	48	Barbour	8.66	Sand clay		Oct. 25	40,838.41	20,419.20
	63	Dale	6.54	do		Oct. 24	35,337.61	17,668.80
	67	do	22.29	do	Oct. 13		138,440.50	69,220.25
	68	Bullock	10.23	do	Oct. 20		78,135.47	39,067.73
	69	Lamar	6.84	Earth and gravel	do		26,581.50	13,290.75
	70	Barbour	3.00	Sand clay	Oct. 10		28,711.01	14,355.50
Arizona.	8	Maricopa	6.641	Concrete or bituminous		Oct. 24	210,978.02	105,489.01
	12	Yavapai	1.961	Macadam		Oct. 2	133,054.11	39,220.00
	16	Pinal and Gila	20.00	Macadam or gravel	Oct. 2		539,803.00	269,901.50
	19	Yavapai	15.144	Earth and gravel	Oct. 10		56,622.15	28,311.07
Arkansas.	31	Cleveland	7.62	Gravel	do		86,216.90	23,000.00
	33	Cross	4.74	do	Oct. 30		41,492.70	12,500.00
	35	Pulaski	8.81	Bituminous	Oct. 16		188,419.60	87,500.00
	36	Washington	41.10	Gravel	Oct. 8		215,229.41	100,000.00
	39	Grant	14.30	do	Oct. 24		52,090.50	15,000.00
California	21	Ventura	5.19	Concrete		Oct. 11	166,885.40	83,442.70
	22	Los Angeles	1.29	do		do	42,310.40	21,155.20
	23	do	5.23	Bituminous		do	100,070.85	50,035.42
	31	Del Norte	4.08	Gravel	Oct. 11		37,510.00	18,755.00
Colorado	11	Yuma	7.49	Earth	Oct. 23		24,036.37	12,018.18
	22	Otero	.407	Concrete		Oct. 24	10,572.92	5,286.46
	27	Mesa	.265	do	Oct. 27		10,286.10	5,143.05
	36	Boulder	1.523	do	Oct. 13		44,855.52	22,427.76
	37	do	1.102	do	do		44,622.88	22,311.44
	43	Kit Carson	18.049	Earth	Oct. 23		43,218.78	21,609.39
	60	Otero	.413	Concrete		Oct. 3	10,605.92	5,286.46
Delaware	5	Kent	5.981	do		Oct. 6	210,143.11	54,000.00
	7	Newcastle	2.01	do	Oct. 20		93,500.00	22,310.61

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Georgia	3	Brooks and Lowndes		Sand-clay		Oct. 23	[1] $21,204.02	[1] $11,584.70
	7	Madison		do		Oct. 3	[1] 48,491.50	24,733.45
	11	Lowndes		2 bridges		do	[1] 16,643.09	12,532.90
	12	Thomas		do		Oct. 24	[1] 17,893.55	[1] 10,463.30
	16	Merriwether	[1] 0.28	Topsoil or sand-clay		Oct. 3	[1] 9,050.10	[1] 5,974.56
	19	Bleckley	[1] 1.48	Earth		do	[1] 12,304.38	[1] 6,308.39
	28	Paulding	9.505	Sand-clay or gravel		do	40,215.91	20,000.00
	29	Emanuel		10 bridges		Oct. 28	140,438.01	70,219.00
	38	Brooks		do		Oct. 25	58,353.29	29,176.64
	42	Chatham	13.534	Brick, concrete, or bituminous		Oct. 3	524,091.08	200,000.00
	44	Hall	4.00	Concrete		do	26,361.24	13,180.62
	49	Mitchell	13.367	Sand-clay		do	67,997.43	33,998.71
	50A	Colquit	.35	Concrete		do	14,128.99	7,000.00
	60	Stephens	11.014	Sand-clay		do	61,298.95	25,000.00
	80		6.00	Concrete or other durable surface	Oct. 4		100,012.00	50,000.00
	82	Lumpkins	8.50	Gravel	Oct. 3		68,558.38	34,279.19
	83	Walton	5.83	Sand-clay	do		29,242.88	14,621.44
	84	do	9.25	do	do		50,757.14	25,378.57
	85	Haralson	5.00	do	do		30,442.50	15,221.25
	86	do	4.00	do	do		29,531.26	14,765.63
	87	do	4.00	do	do		58,338.50	10,013.12
	88	Brooks	7.00	Asphalt, brick, or concrete	do		125,009.50	50,000.00
	89	Baker and Mitchell		Bridge	Oct. 8		60,786.00	30,000.00
	90	Cook	14.70	Concrete	Oct. 3		225,305.41	50,000.00
	91	Lowndes	4.90	Permanent	Oct. 2		99,110.00	49,555.00
	92	Wilkes	5.20	Concrete	do		127,250.20	50,000.00
	93	Taylor and Upson	3.00	Sand-clay	do		44,996.49	22,000.00
	94	Dooley	12.50	do	do		54,851.50	25,000.00
	95	Mitchell	12.20	do	Oct. 3		84,092.80	40,000.00
	96	Floyd	7.25	Bituminous	Oct. 15		89,166.00	44,583.00
	97	Troup	5.15	Sand-clay	Oct. 8		49,410.57	24,705.28
	98	do	5.47	do	Oct. 2		48,375.25	24,187.62
	99	Thomas	4.30	Bituminous	Oct. 8		92,011.59	39,536.69
	100	Terrell	12.50	Sand-clay	Oct. 25		65,869.65	25,000.00
	101	Sumter	3.00	Bituminous	Oct. 8		56,791.10	28,395.55
	102	Cobb	4.00	do	Oct. 24		79,817.65	39,908.82
	103	Chatham	3.306	Concrete or bituminous	Oct. 11		110,003.19	50,000.00
Idaho	18	Latah	22.40	Macadam	Oct. 3		295,630.83	147,815.41
	20	Boundary	18.00	Gravel	do		181,217.00	90,608.50
	21	Bonneville	10.00	Concrete or bituminous	Oct. 13		280,197.39	140,098.69
	22	do	3.00	do	Oct. 10		93,150.20	46,575.10
	25	Bingham	2.00	do	Oct. 18		60,881.70	30,440.85
Illinois	[2] 2	Will, Kankakee, Iroquois	17.113	Bituminous, macadam, and concrete		Oct. 23	578,877.06	289,438.52
	3C	Will	6.788	Brick part way		Oct. 11	213,499.17	106,749.58
	[3] 5	Marshall	12.278	Concrete and earth		Oct. 3	269,557.61	134,778.80
	[3] 5	do	8.465	do		Oct. 20	178,773.43	89,386.71
	[4] 7	Grundy, Bureau, LaSalle, Putnam, and Marshall.	18.112	Concrete			371,362.33	185,681.15
	[5] 8	Madison, Macoupin, Sangamon	19.57	Brick and concrete		Oct. 10	644,481.13	322,240.56
	[5] 8	do	16.459	do	Oct. 23		621,014.45	303,625.42
Indiana	1	Elkhart	6.355	Brick, concrete, or bituminous		Oct. 24	273,761.62	127,100.00
	2	St. Joseph	4.684	do		Oct. 6	192,359.20	93,680.00
	3AB	Marion and Johnson	7.307	do		do	311,774.05	146,140.00
	5	Wayne	1.489	do		do	41,415.60	20,707.80
	6A	Vigo, Putnam, and Clay	7.37	do		Oct. 24	292,354.81	146,177.40
	7	Marion	6.14	do		Oct. 6	197,040.69	98,520.34
	8A	Hamilton and Marion	5.765	do		Oct. 24	226,571.35	113,285.67
	10A	Marshall and St. Joseph	8.398	do		do	301,861.97	150,930.98
	11	St. Joseph and Elkhart	3.501	do		do	128,796.91	64,398.45
	12	Jackson	2.462	do		Oct. 6	75,377.44	37,688.72
	13A	Hancock and Henry	8.854	do		Oct. 24	253,069.59	126,534.79
Iowa	10	Calhoun	18.36	Gravel		Oct. 11	130,754.30	65,000.00
	37	Buena Vista	12.86	do	Oct. 24		45,267.20	22,600.00
	39	Greene	7.41	Brick or concrete	Oct. 2		293,920.00	146,900.00
	43	O'Brien	22.59	do	Oct. 23		832,426.00	416,000.00
	50	Davis	10.20	Earth	do		62,310.60	31,150.00
	51	Guthrie	20.00	do	do		140,586.60	70,200.00
	52	Audubon	26.25	do	Oct. 29		149,842.00	74,900.00
	56	Henry	20.90	do	Oct. 23		91,377.00	45,500.00
	60	Van Buren	11.10	do	do		54,120.00	27,000.00
	62	Black Hawk	17.10	Brick or concrete	Oct. 20		757,697.60	342,000.00
	77	Fremont	18.50	Earth	Oct. 23		147,400.00	73,700.00
	84	Sioux	3.00	Brick or concrete	Oct. 3		108,872.50	54,400.00
	93	Howard	11.00	Gravel	Oct. 23		84,851.25	42,400.00
	94	Hancock	23.90	Brick or concrete	Oct. 20		953,350.20	476,600.00
	109	Palo Alto	11.00	do	Oct. 23		256,817.00	128,400.00
Kansas	31	Geary and Dickinson	.308	do		Oct. 24	10,971.13	4,620.00
	34	Bourbon	5.91	Bituminous	Oct. 2		172,260.00	86,130.00
	37	Montgomery	12.14	Gravel	Oct. 3		295,020.00	147,510.00
Kentucky	6	Rockcastle	6.818	Earth		Oct. 3	89,754.21	44,877.10
Louisiana	10	Richland	[1] 1.91	Gravel		Oct. 6	[1] 19,923.43	[1] 9,961.21
	38	Natchitoches	17.89	do		Oct. 25	214,546.47	107,273.23
	43	Calcasieu	11.79	Shell and gravel		Oct. 24	245,092.59	122,546.29
	45	Caddo	8.35	Gravel		do	65,945.27	32,972.63
	47	East Carroll	35.06	do	Oct. 31		306,972.37	183,486.18
Maryland	15A	Baltimore	2.03	Concrete		Oct. 11	71,402.98	35,701.49
	24A	Allegany	3.86	do		do	253,152.88	77,200.00
	26A	Baltimore	1.99	do		do	51,819.46	25,909.73
	33AB	Carroll	2.08	do		do	72,155.54	36,077.77
	35	Washington	9.50	do	Oct. 2		331,650.00	165,825.00
	37	Queen Anne and Kent	19.00	do	Oct. 30		660,000.00	330,000.00
Massachusetts	27	Essex	3.559	Bituminous	Oct. 3		73,488.57	36,744.28
	28	Berkshire	3.66	Concrete	do		141,110.75	70,555.37
Michigan	35	Jackson and Washtenaw	25.559	Brick, concerete, or bituminous	Oct. 8		1,018,050.00	509,025.00
	42	Wayne	14.211	Concrete	Oct. 28		627,110.00	287,850.00
Minnesota	38	Mower	24.60	Earth		Oct. 8	149,788.29	70,000.00
	39	Fillmore	8.30	Gravel		Oct. 6	94,156.38	47,000.00

[1] Modified agreements. Amounts given are increases over those in the original agreements.

[2] Includes sections 3, 8, 9, 10, and H-15d of project.

[3] First agreement on project 5 includes sections B, C, D, and G-15d and second sections E and M.

[4] Agreement is for sections A, C, D, and F-29a of project No. 7.

[5] The first of project 8 agreements is for sections D and E and the second for sections G, I, F, and J-15d.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Minnesota	41	Isanti	5.52	Gravel		Oct. 16	$48,574.13	$24,287.06
	49	Chippewa	15.09	do		Oct. 3	85,586.53	40,000.00
	50	Mahnomen	3.99	do		Oct. 16	15,238.02	7,500.00
	53	Lyons	9.05	do		Oct. 14	93,157.91	46,000.00
	78	Yellow Medicine	14.09	do	Oct. 10		49,852.66	24,926.33
	83	Pennington	4.70	do			31,154.14	15,577.07
	86	Aitken	10.30	do	Oct. 15		61,369.00	30,684.50
	88	Chippewa	5.00	do	Oct. 14		49,410.84	24,705.42
	90	Rock	6.00	Concrete	Oct. 3		213,071.65	106,535.82
	94	Polk	9.9	Gravel	Oct. 6		64,271.07	32,135.53
	101	Cottonwood	8.07	do	Oct. 28		68,901.37	34,450.68
Mississippi	14	George		Sand-clay		Oct. 13	[1] 5,927.69	[1] 6,358.68
	48	Yazoo	4.00	Concrete	Oct. 11		103,400.00	51,700.00
	61	Sharkey	13.10	do	Oct. 8		342,531.64	100,000.00
	81	Bolivar	4.47	do	Oct. 1		108,432.50	54,216.25
Missouri	7A	Mississippi	15.30	Gravel		Oct. 14	444,442.86	222,221.43
	20	Cass	19.00	Macadam	Oct. 8		170,869.88	85,434.94
	23	Pettis	5.30	Bituminous	Oct. 2		60,761.80	30,380.90
	27	Cooper	7.80	do	do		129,438.10	64,719.05
	30	Morgan	11.10	Gravel	Oct. 3		46,123.00	23,061.50
	31	Washington	3.53	do	Oct. 11		12,053.02	6,026.51
	33	Polk	13.80	do	Oct. 31		58,294.50	29,147.25
	34	Pemiscot	5.50	do	Oct. 30		51,324.24	25,662.12
	35	do	6.00	do	Oct. 23		69,863.20	34,931.60
	36	Christian	9.50	do	Oct. 30		35,382.60	17,691.30
	37	Gentry	8.17	do	Oct. 28		186,313.60	93,156.80
	39	Lewis	7.70	do	Oct. 30		67,759.67	33,879.83
	40	New Madrid	19.00	do	do		189,999.23	94,999.61
	41	Pemiscot	4.50	do	do		42,619.22	21,309.61
Montana	13	Park	4.13	do		Oct. 25	21,994.66	10,997.33
	18	Custer	3.99	do		Oct. 6	21,954.62	10,977.31
	35	Wibaux	5.68	do		Oct. 20	24,221.83	12,110.91
	39	Ravalli		Bridge		Oct. 25	20,751.50	10,375.75
	47	Carter	13.00	Earth	Oct. 3		22,000.00	11,000.00
	52	Yellowstone	2.00	Gravel	Oct. 8		63,910.00	31,955.00
	57	do	1.10	Concrete	Oct. 16		40,920.00	20,460.00
Nebraska	3	Hall		Earth		Oct. 4	[1] 84,262.97	[1] 42,131.48
	5	Madison and Platte	[2] .22	Earth and sand-clay		Oct. 11	[2] 12,425.20	[2] 6,212.60
	20	Douglas	15.04	Earth		Oct. 25	49,865.76	24,932.88
	32	Adams and Webster	27.31	do		Oct. 4	138,829.44	69,414.72
	46	Red Willow	17.14	do		do	107,310.12	53,655.06
	61	Blaine	9.40	Sand-clay	Oct. 24		46,750.00	23,375.00
	77	Adams	11.28	Earth		Oct. 16	60,793.30	30,396.65
	81	Dodge	5.94	Concrete		Oct. 27	199,440.34	60,221.17
	96	Custer	30.20	Sand-clay	Oct. 30		107,250.00	53,625.00
	101	Scottsbluff	6.25	Gravel	Oct. 6		46,156.00	23,078.00
	103	do		Bridge	do		107,030.00	53,515.00
Nevada	24	Churchill	17.30	Gravel or macadam	Oct. 18		220,440.00	110,220.00
	25	White Pine	.28	Sand-clay or gravel	do		8,525.00	4,262.50
New Hampshire	33	Rockingham	3.052	Gravel		Oct. 3	17,967.62	8,983.81
	35	do	1.022	Macadam		Oct. 2	13,261.49	6,630.74
	38	Hillsborough	1.04	Bituminous		Oct. 3	13,446.68	6,723.34
	43	Rockingham	1.023	Gravel		do	10,323.96	5,161.98
	46	do	.98	Macadam		do	13,165.02	6,582.51
	63	do	.758	Gravel		do	7,407.07	3,703.53
	64	do	.79	do		do	10,220.65	5,110.32
	65	do	1.22	do			13,266.00	6,633.00
	67	Strafford	.80	do		do	7,328.09	3,664.04
	69	Cheshire and Sullivan	.511	do		Oct. 11	8,998.99	4,449.49
	77	Hillsborough	.455	do		Oct. 16	7,564.70	3,782.35
	80	Rockingham		Bridge		Oct. 11	5,839.90	2,919.95
	82	Merrimack	.47	Gravel	Oct. 4		9,444.49	4,722.24
	83	Strafford	1.028	do	Oct. 3		14,572.03	7,286.01
	86	Merrimack	.673	do	Oct. 8		7,775.98	3,887.99
	87	do	.54	do	Oct. 6		9,997.79	4,998.89
	89	do	.71	do	Oct. 15		14,303.30	7,151.65
New Jersey	14	Somerset and Middlesex	3.665	Concrete		Oct. 13	94,642.14	44,348.91
	17	Burlington	3.313	do	Oct. 18		362,808.00	101,760.00
	18	Mercer	1.648	do	Oct. 6		92,601.38	32,960.00
	19	Mercer and Middlesex	1.448	do	Oct. 31		132,509.00	43,960.00
New Mexico	1A	Colbax		Gravel		Oct. 6	[1] 41,746.79	[1] 20,873.40
	3	Santa Fe		do		do	[1] 35,637.41	[1] 17,878.71
	4	Valencia		Graded earth surfaced where needed		Oct. 24	[1] 3,264.95	[1] 1,632.47
	11	Lincoln	5.396	Gravel		Oct. 28	42,661.08	21,330.54
	12	Chaves		Gravel and macadam		Oct. 23	[1] 18,248.68	[1] 9,124.34
	15	Dona Ana		Concrete		Oct. 6	[1] 76,031.39	[1] 38,015.69
	16	Lea	5.439	Macadam		Oct. 30	39,517.23	19,758.61
	28	Grant	16.00	Gravel	Oct. 30		239,475.50	119,737.75
	36	Sandoval	6.00	do	Oct. 14		48,378.00	24,189.00
	38	Union	11.10	do	Oct. 4		70,133.25	35,066.62
North Carolina	8	Cumberland	13.46	Sand-clay and gravel		Oct. 14	62,800.71	31,400.35
	25	Person	8.175	Sand-clay		Oct. 2	85,431.75	42,715.87
	47	Guilford	4.607	Asphalt or concrete		Oct. 3	141,105.71	70,552.85
	49	Lenoir	6.017	do		Oct. 16	192,712.42	96,356.21
	50	Guilford	2.003	Bituminous		Oct. 13	58,564.93	29,282.46
	53	Lenoir	7.46	Concrete	Oct. 6		232,105.50	116,052.75
	56	Forsyth	5.90	Sand-clay	Oct. 23		38,501.80	19,250.90
	58	Johnson	7.80	Gravel	Oct. 8		46,268.02	23,134.01
	59	Columbus	12.31	Sand-clay	Oct. 31		53,892.52	26,946.26
	60	Lenoir	7.87	Concrete	Oct. 6		244,048.09	122,024.04
	62	Buncombe	3.43	Macadam	Oct. 23		89,098.22	44,549.11
	63	Buncombe	3.68	do	Oct. 6		116,818.08	58,409.04
	64	Carteret	14.30	Concrete	Oct. 10		267,339.60	133,669.80
	66	Haywood	6.20	Sand-clay	Oct. 6		56,954.92	28,477.46
	67	Nash	10.00	Concrete	Oct. 8		341,550.00	170,775.00
	69	Transylvania	9.50	Sand-clay or gravel	Oct. 24		72,445.95	36,222.97
	70	Jackson	12.00	do	Oct. 20		169,587.00	84,793.50
	72	Anson	5.93	do	Oct. 6		54,724.56	27,362.28
	73	Nash	9.10	Sand-clay	Oct. 13		143,085.07	71,542.53
	74	Stanley	6.59	do	Oct. 6		69,113.22	34,556.61
	76	Cabarrus	1.35	Bituminous	Oct. 20		47,910.50	23,955.61

[1] Modified agreements. Amounts given are increases over those in the original agreements.

[2] Modified agreement. There is a decrease in the mileage, but increases in the estimated cost and Federal-aid allowance in the original agreement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
North Carolina	77	Rutherford	2.19	Concrete	Oct. 20		$67,548.03	$33,774.01
	89	Franklin and Nash	10.00	Sand-clay	Oct. 23		71,390.28	35,695.14
North Dakota	21	Bowman	17.90	Graded earth		Oct. 25	[1] 6,638.03	[1] 3,319.01
	54	Kidder	3.70	Earth and gravel	Oct. 2		12,000.00	6,000.00
	56	Stutsman	40.50	Earth	Oct. 4		143,000.00	71,500.00
	58	Sargent	19.50	do	Oct. 20		86,000.00	43,000.00
	59	Richland	14.50	do	do		52,200.00	26,100.00
	60	do	34.00	do	do		115,600.00	57,800.00
	64	Logan		Bridge	Oct. 8		6,600.00	3,300.00
	65	Stark		do	Oct. 28		8,800.00	4,400.00
	67	Traill	5.00	Earth	Oct. 20		16,500.00	8,250.00
	70	Nelson	5.50	do	do		20,570.00	10,285.00
	72	Richland	18.00	do	do		54,540.00	27,270.00
Ohio	19	Summit	16.707	Brick		Oct. 3	905,300.00	213,000.00
	21	Guernsey	1.26	Concrete		do	40,600.00	20,300.00
	22	do	3.13	Grading, bridges and culverts		do	119,000.00	59,500.00
	27	Hamilton	6.623	Asphalt, concrete or brick		Oct. 2	415,400.00	132,400.00
	32	Crawford	2.726	Brick or bituminous		Oct. 10	115,500.00	48,500.00
	37	Knox	5.08	Concrete or brick		Oct. 3	203,000.00	50,000.00
	41	Trumbull	9.88	Macadam or concrete		do	353,000.00	80,000.00
	45	Lorain	1.206	Concrete		Oct. 25	49,800.00	6,500.00
	55	Miami	3.59	do		Oct. 3	106,000.00	20,000.00
	56C	Montgomery	3.096	do		do	98,000.00	25,000.00
	56AB	do	3.04	do		do	104,100.00	45,000.00
	59C	Fayette	4.11	Macadam or bituminous		Oct. 8	99,400.00	41,100.00
	64	Hamilton	5.994	Brick, concrete or bituminous		Oct. 2	371,300.00	119,800.00
	67CEG	Logan	8.18	Concrete		Oct. 3	273,100.00	122,900.00
	71	Darke	4.611	do		do	158,000.00	45,000.00
	72	do	4.506	do		do	129,000.00	45,000.00
	73	do	4.317	do		do	178,000.00	45,000.00
Oklahoma	18	Muskogee	38.00	Gravel	Oct. 2		399,300.00	199,650.00
Oregon	11	Baker	4.43	Graded and drained earth		Oct. 2	56,068.10	25,034.05
	15	Harney	16.73	Gravel macadam		Oct. 3	217,763.70	108,881.85
	24	Gillian	14.95	Earth	Oct. 23		251,915.95	125,957.97
	25	Sherman	14.70	do	do		248,050.00	124,025.00
	28	Malheur	9.10	Gravel	Oct. 8		61,074.58	30,537.29
	29	Coos and Douglas	14.20	Gravel or macadam	Oct. 23		584,056.00	284,000.00
Pennsylvania	20B	Adams, Cumberland and York	7.70	Concrete or bituminous		Oct. 25	327,698.80	154,000.00
	58	Fayette	4.982	Brick or concrete		Oct. 8	334,930.75	99,640.00
Rhode Island	6	Providence	2.90	Bituminous	Oct. 10		123,310.88	58,000.00
South Carolina	2	Spartanburg		Concrete or brick		Oct. 6	[1] 11,310.10	[1] 9,127.51
	15	McCormick		Bridge		Oct. 25	32,991.24	16,495.62
	22	Charleston	3.987	Concrete		Oct. 24	151,041.42	71,744.66
	25	Lexington	23.97	Sand-clay		Oct. 8	86,299.37	43,149.68
	27	Spartanburg	4.001	do	Oct. 20		33,040.38	16,520.19
	29	Laurens	14.316	do	Oct. 23		94,961.83	47,480.91
	30	Pickens	5.69	do	Oct. 20		51,234.88	25,617.44
	34	Chesterfield	3.117	Gravel	Oct. 11		16,254.37	8,000.00
	35	do	3.281	Sand-clay	Oct. 23		12,679.48	6,000.00
	42	Sumter	9.787	do	Oct. 10		141,578.23	20,000.00
South Dakota	13	Davison	13.95	Gravel		Oct. 2	98,316.07	49,158.03
	20	Walworth	17.30	Earth and gravel	Oct. 2		82,775.00	41,387.50
	21	Aurora	7.76	Gravel	do		66,830.50	33,415.25
	22	Day	28.31	do	do		204,749.05	102,374.52
	23	Jackson and Washabaugh		Bridge	Oct. 8		26,646.00	13,323.00
	24	Hanson	27.34	Gravel	Oct. 20		128,457.34	64,228.67
	26	Kingsbury	13.41	do	Oct. 24		116,579.10	58,289.55
	27	Tripp	6.00	Earth	Oct. 20		56,991.00	28,495.50
	28	Charles Mix	17.54	Gravel	Oct. 24		113,989.70	56,994.85
Tennessee	3	Franklin		Waterbound macadam		Oct. 2	[1] 39,150.02	[1] 19,575.01
	4	Moore and Rutherford		Macadam and gravel		do	[1] 42,359.77	[1] 23,252.64
	8	Shelby	16.039	Bituminous	Oct. 3		370,545.33	185,272.66
	10	Henry	19.539	Gravel	Oct. 11		314,221.05	157,110.52
	14	Grainger, Hawkins and Sullivan	48.876	Macadam	Oct. 2		721,134.47	360,567.23
	15	Madison		Bridge	Oct. 13		16,091.57	8,045.78
	16	Montgomery		do	Oct. 11		176,543.40	88,271.70
	17	Overton	13.245	Macadam	do		251,244.57	125,622.28
Texas	43	Tarrant	5.80	Concrete	Oct. 2		245,982.18	116,000.00
	46	Gillespie	[2] 10.00	Gravel	Oct. 31		[2] 192,951.00	[6] 81,000.00
	84	Van Zandt	9.889	do		Oct. 2	110,135.19	40,000.00
	85	Freestone	10.04	Gravel or macadam		do	111,048.80	37,500.00
	86A	Montague	9.839	Gravel		do	101,358.08	50,679.04
	90	Taylor	20.66	Earth and gravel	Oct. 20		66,128.58	30,030.00
	91	do	2.998	Gravel		Oct. 2	13,618.48	4,950.00
	95	Red River	2.18	Concrete and gravel		do	30,087.88	15,000.00
	101	McLennan	1.01	Concrete	Oct. 31		41,899.00	20,000.00
	102	Henderson	11.66	Gravel	Oct. 3		108,984.06	30,000.00
	103	Milam	9.07	do	Oct. 31		40,002.60	20,000.00
	105	Wood	11.50	do	Oct. 2		83,028.00	41,500.00
	108	Kendall	5.778	do	Oct. 31		42,635.17	21,000.00
	109	Wood	21.70	do	do		168,364.22	63,500.00
	114	De Witt	12.10	do	do		72,170.01	36,085.00
Vermont	6	Orange	2.35	Gravel or macadam		Oct. 3	38,015.01	19,007.50
	11	Chittenden	1.40	Concrete or bituminous		do	47,973.80	23,986.80
Virginia	24	Alleghany	8.03	Slag macadam		Oct. 16	87,294.68	43,647.34
	43	Albemarle	7.50	Macadam	Oct. 3		130,625.00	65,312.50
	57	Pulaski	4.07	do	Oct. 4		57,970.00	28,985.00
	60	Lee	5.00	do	Oct. 6		87,120.00	43,560.00
Washington	17	Whatcom	2.70	Concrete		Oct. 25	116,682.13	54,000.00
	30	Skagit	7.70	do		Oct. 3	269,130.70	134,565.35
	31	Lewis		Bridge		Oct. 25	35,076.14	17,538.07
	33	Clarke	4.25	Concrete		Oct. 3	141,805.00	70,902.50
	34	do	6.62	do		Oct. 20	226,033.84	113,016.92
	36	do	3.32	do		Oct. 16	95,229.53	47,614.76
	38	Yakima	2.94	do		Oct. 3	105,478.05	52,739.02
	39	do	5.03	do		do	158,361.96	79,180.98
	42	Grays Harbor	4.20	do		do	130,559.93	65,279.96
	43	do	2.82	do		do	84,650.02	42,325.01
	44	Clarke	4.03	do	Oct. 6		164,677.26	60,000.00
	45	do	2.16	Earth	Oct. 28		91,033.25	43,200.00

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[1] Modified agreements. Amounts given are increases over those in the original agreements.

[2] Revised project statement. Amounts given are increases over those in those in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS FOR OCTOBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
West Virginia	29	Ritchie	5.00	Concrete		Oct. 14	$160,654.65	$41,650.00
	45	Putnam	4.00	Brick, concrete or bituminous		do	125,152.30	48,000.00
	68	Nicholas	2.00	Earth		do	29,229.20	14,614.60
	73	Mineral	12.00	Gravel	Oct. 11		71,534.00	35,744.00
	79	Pocahontas	5.57	Bituminous	Oct. 20		84,370.00	42,185.00
	80	Marshall	.485	Brick	Oct. 11		23,700.00	9,700.00
	81	Tyler	1.50	Concrete	Oct. 23		40,360.00	15,360.00
	82	Gilmer	10.00	Earth	do		57,250.00	28,625.00
	83	Lewis	2.00	Brick or concrete	do		88,390.00	18,390.00
Wisconsin	66	Richland	[1] .41	Concrete		Oct. 11	[1] 5,412.60	[1] 1,804.19
	81	Trempealeau	4.74	Gravel		Oct. 13	68,391.49	22,797.16
	88	Sawyer	4.315	Earth		Oct. 3	29,457.29	9,819.09
	92	Brown	5.14	Concrete		Oct. 25	122,617.78	40,872.59
	96	Rock	5.99	do		Oct. 23	159,842.07	53,280.69
	100	Grant	1.135	Earth	Oct. 31		27,000.00	9,000.00
	103	Milwaukee	1.50	Concrete		Oct. 14	44,446.68	14,815.56
Wyoming	6	Converse	[2] 7.50	Earth	Oct. 10		[2] 7,689.00	[2] 3,844.50
	7	Minta	[2] 1.50	Graded and drained earth	do		[2] 2,242.02	[2] 1,121.01
	8	Park		Bridges	do		[2] 8,564.52	[2] 4,282.26
	24	Lincoln	4.18	Earth		Oct. 3	37,554.88	18,777.44
	28	Sheridan	4.164	Macadam		Oct. 10	51,574.93	25,787.46
	31	Natrona	1.218	Bituminous or concrete	Oct. 28		170,098.50	77,710.00
	34	Lincoln	17.49	Macadam		Oct. 13	131,682.35	65,841.17
	35	Platte	12.74	Gravel		Oct. 14	102,403.88	51,201.94
	43	do	7.00	Earth	Oct. 6		19,690.00	9,845.00
Total	347		2,737.046				44,729,869.37	20,444,949.11

[1] Modified agreements. Amounts given are increases over those in the original agreements.

[2] Statements previously approved withdrawn.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	11	Lowndes	0.75	Gravel		Sept. 9	$28,490.31	$14,245.15
	49	Limestone	9.97	do		Sept. 2	53,185.89	26,592.94
	52	Calhoun	4.00	Macadam	Sept. 4		53,154.26	26,577.13
	54	Coosa	1.50	Sand-clay	Sept. 10		7,990.40	3,995.20
	66	Lauderdale	1.96	Gravel	Sept. 30		20,558.23	10,279.11
Arkansas	23	Jackson	8.85	do		Sept. 11	86,416.88	40,000.00
	27	Columbia	14.03	Macadam	Sept. 16		53,807.60	23,046.05
	30	Franklin	23.79	Gravel	Sept. 26		147,571.60	70,000.00
	32	Hempstead	8.07	do	Sept. 30		76,823.01	25,000.00
California	15	Monterey	.50	Bridge, concrete		Spet. 11	285,403.58	142,701.79
	20	Lake	9.36	Earth		Sept. 2	116,807.02	58,354.01
	27	Tuolumne	12.79	Concrete	Sept. 10		279,152.50	139,576.25
	28	Placer	6.60	do	do		147,895.00	73,947.50
	29	Amador	10.74	Earth	do		71,940.00	35,970.00
	30	Tuolumne	21.90	Concrete	Sept. 29		452,390.40	226,195.20
Colorado	2	Huerfano-Los Animas		Brick or concrete and gravel, limestone or basalt base.		Sept. 26	[1] 239,290.71	[1] 119,645.36
	7A	Montrose	2.102	Graded and drained earth		Sept. 11	26,075.35	13,037.67
	13	Boulder	.417	Concrete		Sept. 30	10,485.41	5,237.70
	14	do	.504	do		Sept. 27	20,628.77	10,314.38
	33	Larimer	2.765	do	Sept. 27		74,983.59	37,491.79
	92	Pueblo		Bridge	Sept. 29		69,850.00	34,925.00
Florida	17	Manatee	10.28	Brick or concrete	Sept. 8		207,650.54	103,825.27
	18	Putnam	12.72	Asphalt or concrete	Sept. 20		302,265.70	151,132.85
	19	Hamilton	7.12	Asphalt, brick or concrete	do		172,776.73	86,388.36
Georgia	79	Bibb	6.57	Concrete	Sept. 2		193,831.00	80,855.20
	81	Dougherty		Bridge	Sept. 5		245,498.00	110,000.00
Idaho	16	Jefferson	7.51	Earth	Sept. 10		90,000.00	45,000.00
Illinois	25	Kankakee and Iroquois		Bituminous, macadam, or concrete		Sept. 30	[2] 23,873.66	[2] 11,936.83
	2	do	10.70	do	Sept. 20		[3] 837,001.80	[3] 463,735.90
	10	Will and Grundy	20.80	Concrete	Sept. 29		739,384.60	369,692.30
	11	Vermillion	19.53	Brick	Sept. 27		419,325.00	209,662.50
Indiana	14	Vigo	4.70	Asphalt, brick, or concrete	Sept. 10		183,585.60	91,792.80
	16	Vanderburgh, Warrick, Spencer, Dubois, Orange, and Lawrence.	114.40	do	do		4,223,076.00	2,111,538.00
	17	Lake, Porter, and Laporte	56.70	do	Sept. 20		2,292,351.00	1,134,000.00
	18	Tipton and Howard	10.00	Brick, concrete, or bituminous	Sept. 27		429,000.00	200,000.00
Iowa	13	Webster	12.15	Gravel		Sept. 20	132,639.23	28,233.08
	24	Polk	7.75	do			[1] 67,721.50	[1] 23,041.07
	54	Scott	8.46	Brick or concrete	Sept. 29		400,563.62	169,000.00
	61	Cerro Gordo	6.00	do	Sept. 20		242,611.60	120,000.00
	104	Polk	6.50	do	Sept. 29		337,147.25	130,000.00
Kansas	7	Douglas	18.289	Concrete		Sept. 10	767,828.56	274,342.50
	19	Allen	4.527	Gravel or macadam		Sept. 29	87,726.28	43,863.13
	29	Dickinson	25.07	Asphalt, brick, or concrete	Sept. 4		1,119,648.47	376,050.00
	31	Geary and Dickinson	.31	Concrete	do		10,971.12	4,650.00
	32	Dickinson	10.40	Brick or concrete	do		486,670.80	156,000.00
	35	Sumner	44.50	Concrete	Sept. 29		1,622,808.00	667,500.00
	36	Cherokee	7.00	do	do		258,656.20	105,000.00
Kentucky	14	Nelson	3.00	Rock, asphalt, or bituminous	Sept. 10		49,981.80	24,990.90
	17	Clark	6.60	Bituminous	Sept. 27		119,925.63	59,962.81
	18	Jefferson	4.50	Concrete	do		180,000.72	90,000.00
Louisiana	39	Concordia	18.10	Gravel		Sept. 29	200,226.40	100,113.20
	42	Jefferson	13.58	do		Sept. 30	135,493.09	67,746.54
Maryland	2B	Prince Georges	.91	Cement concrete		Sept. 20	26,414.85	13,207.42
	3	Allegany		do		Sept. 16	[1] 43,205.75	[1] 23,300.00

[1] Modified agreements. Amounts given are increases over those in the original agreement.

[2] Modified agreement. Amounts given are reductions over those in the original agreement.

[3] Revised statement. Figures given are increases over those in the original statement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Maryland	4	Garrett	2.12	Concrete		Sept. 20	$80,671.27	$40,335.63
	7B	Baltimore and Hartford	1.36	do		Sept. 30	40,268.80	20,134.40
	25	Charles	7.00	Gravel	Sept. 10		132,000.00	66,000.00
	31	do	7.20	do	do		143,000.00	71,500.00
	32	St. Marys	6.25	do	Sept. 20		117,700.00	58,850.00
	33	Carroll	1.100	Concrete	Sept. 4		[1] 39,179.25	[1] 39,614.00
	34	Anne Arundel	6.50	Gravel	Sept. 29		121,000.00	60,500.00
	36	do	9.00	Concrete	Sept. 30		396,000.00	180,000.00
Massachusetts	17	Essex	1.794	Bituminous	Sept. 20		61,136.51	30,568.25
	22	Franklin	6.36	Bituminous and gravel	Sept. 10		129,357.69	64,678.84
	24	Bristol	2.756	Bituminous		Sept. 30	39,055.50	19,527.75
	26	Franklin	9.558	Concrete	Sept. 20		414,782.11	191,160.00
Michigan	13	Livingston		Gravel		Sept. 16	[2] 98,679.02	[2] 49,339.51
	27	Charlevoix	5.447	Concrete		do	161,073.85	80,536.92
	34	Washtenaw	1.260	Concrete or bituminous		Sept. 30	[3] 8,537.10	[3] 4,268.55
Minnesota	15	Becker		Gravel		Sept. 16	[2] 21,234.19	[2] 25,069.22
	28	Grant	1.96	do	Sept. 20		[1] 29,746.28	[1] 15,873.14
	43	Cottonwood	4.07	do		Sept. 5	25,001.75	12,000.00
	54	Lac qui Parle	38.51	do		Sept. 30	68,213.39	30,000.00
	55	do	6.47	do		Sept. 20	9,620.35	4,000.00
	56	do	16.93	do		Sept. 30	33,398.17	16,000.00
	57	Beltrami	29.76	do	Sept. 9		153,580.05	76,000.00
	60	Sherburne	6.51	Asphalt, brick, or concrete		Sept. 11	229,169.24	114,584.62
	62	Dodge	6.87	Gravel	Sept. 27		[1] 48,012.89	[1] 23,631.92
	66	Big Stone	10.50	do	Sept. 19		53,955.00	26,977.50
	68	Rice	4.63	do	Sept. 5		29,865.00	14,932.57
	69	do	4.31	do	Sept. 20		20,024.40	10,012.20
	70	Cook	4.50	do	Sept. 19		36,862.54	18,431.20
	71	Martin	5.50	do	do		44,792.44	22,396.22
	72	do	4.60	do	do		47,758.92	23,879.46
	73	Crow Wing	3.64	Concrete	do		107,944.76	53,972.38
	75	Murray	17.70	Gravel	Sept. 23		150,306.20	50,000.00
	76	Morrison	12.03	do	Sept. 27		46,349.09	23,174.54
	77	Rice	5.50	do	Sept. 10		43,796.91	21,898.45
	81	Marshall	26.65	do	Sept. 27		139,304.88	55,000.00
	82	Pipestone	11.55	Concrete	Sept. 10		378,840.00	189,420.00
	84	St. Louis	1.13	do	Sept. 9		50,000.12	20,000.00
	85	Cottonwood	5.42	Gravel	Sept. 27		33,742.83	15,871.41
	87	Yellow Medicine	6.00	do	Sept. 10		21,473.32	10,736.66
Mississippi	53	Adams	11.80	do	Sept. 29		119,174.00	59,587.00
	77	Jackson	2.64	Concrete	Sept. 18		92,529.89	46,264.94
Missouri	18	do	3.07	Bituminous macadam		Sept. 30	61,394.83	30,697.41
	21	Ripley	13.50	Earth and gravel	Sept. 18		28,292.00	14,146.00
	22	Randolph	1.75	Brick or concrete	Sept. 20		56,124.20	28,062.10
	24	Cooper	5.55	Bituminous	Sept. 29		88,578.60	44,289.30
	25	Clay	13.07	do	Sept. 26		324,572.21	162,286.10
	28	St. Charles	1.66	do	do		22,736.56	11,368.28
	29	Saline	9.20	do	Sept. 25		168,013.76	84,006.88
Montana	48	Fallon	26.00	Earth	Sept. 29		33,000.00	16,500.00
	53	Yellowstone	37.00	Gravel	Sept. 18		164,984.60	82,492.30
	55	Ravalli		Bridge	Sept. 26		22,000.00	11,000.00
	59	Park	14.50	Gravel	Sept. 27		47,685.00	23,842.50
	60	do	29.00	do	Sept. 29		135,520.00	67,760.00
Nebraska	21	Box, Butte, and Sheridan		do		Sept. 11	[3] 519.19	[3] 259.60
	36	Chase and Hayes		Earth		do	[2] 2,828.45	[2] 1,414.23
	28	Casa and Otoe	.48	do		do	[2] 813.90	[2] 496.95
	29	Butler		do		do	[2] 2,716.78	[2] 1,358.39
	30	Furnas	19.42	do		Sept. 27	87,993.21	43,996.60
	66	Cherry	24.70	Earth and sand-clay	Sept. 20		87,857.00	43,928.50
	68	Hitchcock and Red Willow	24.20	Sand-clay	Sept. 19		87,348.80	43,674.40
	69	Banner and Ocott's Bluff	25.85	Earth	Sept. 10		73,370.00	36,685.00
	80	Grant	13.20	Earth and sand-clay	do		44,105.60	22,052.80
	83	Antelope and Boone	33.90	do	Sept. 4		79,200.00	39,600.00
	85	Garfield, Greeley, and Valley	42.00	do	Sept. 23		113,740.00	56,870.00
	88	Burt, Cumming, and Dodge	21.20	Earth	Sept. 27		60,500.00	30,250.00
	99	Thomas	14.80	Sand-clay	Sept. 19		59,778.40	29,889.20
	104	Hall	3.00	Gravel	do		23,799.58	11,889.79
	105	Dawson	13.40	do	do		45,016.40	22,508.20
	106	Gage	1.117	Brick or concrete	Sept. 29		58,287.29	22,340.00
Nevada	21	Washoe	.97	Concrete		Sept. 12	42,407.07	19,400.00
New Hampshire	21	Cheshire and Coos	3.59	Gravel		Sept. 20	16,214.31	8,107.00
	24	Grafton and Hillsborough	.95	Bituminous		Sept. 2	12,628.39	6,314.19
	26	Merrimack	.87	Gravel		Sept. 20	9,892.52	4,946.26
	28	Grafton and Merrimack	1.06	do		do	14,749.02	7,374.51
	50	Cheshire	1.25	Bituminous macadam		do	19,299.77	9,649.88
	51	do	.853	Bituminous		do	11,665.08	5,832.54
	55	Strafford	1.25	Gravel	Sept. 10		10,043.00	5,021.50
	57	Cheshire	1.09	do	Sept. 4		11,905.19	5,952.59
	60	do	2.17	do	do		20,006.36	10,003.18
	62	Strafford	.80	do	Sept. 20		7,938.15	3,969.07
	71	do	1.22	do	Sept. 4		16,810.97	8,405.48
	72	Merrimack	1.10	do	Sept. 20		15,984.10	7,992.05
	74	Carroll	1.27	Macadam	Sept. 10		14,903.55	7,451.77
	76	Hillsborough	1.34	Gravel	do		16,888.03	8,444.01
	77	do	.59	do	do		7,286.51	3,643.25
	78	Rockingham	1.50	do	Sept. 20		12,001.55	6,000.77
	79	do	1.136	do	do		7,590.44	3,795.22
	80	do		Bridge	Sept. 10		7,777.00	3,888.50
	81	Grafton		do	Sept. 20		15,000.00	7,500.00
	84	do		do	do		13,000.00	5,000.00
	85	Merrimack	.47	Gravel	Sept. 19		3,812.32	1,906.16
New Jersey	4	Monmouth	[1] 1.328	Concrete		Sept. 5	[2] 76,918.63	[2] 26,258.76
	15	Middlesex and Union	3.55	do	Sept. 4		303,185.41	71,000.00
New Mexico	24	Roosevelt	15.00	Gravel	Sept. 27		123,475.00	61,737.50
	25	Curry	15.00	do	do		122,353.00	61,176.50
	32	San Miguel	15.00	Gravel or macadam	Sept. 10		182,593.13	91,296.51
	33	Mora	13.50	Gravel	do		135,303.30	67,651.65
	34	Rio Arriba	20.00	do	Sept. 4		108,020.00	54,010.00
	35	San Juan	17.00	do	Sept. 20		51,620.80	25,810.40
North Carolina	43	Beaufort	2.20	Concrete		Sept. 11	95,089.62	44,000.00

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[1] Revised statement. Figures given are increases over those given in the original statement

[2] Modified agreements. Amounts given are increases over those in the original agreement.

[3] Modified agreement. Amounts given are reductions over those in the original agreement.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
Noath Carolina	65	Pitt	9.60	Concrete	Sept. 20		$325,608 80	$162,804.40
	71	Durham	6.30	Bituminous	Sept. 26		236,445.00	118,222.50
North Dakota	6	Eddy		Gravel and earth		Sept. 26	[1] 7,495.16	[1] 3,747.58
	19	Ramsey	17.10	Graded earth		Sept. 2	20,122.58	10,061.29
	25	Ward	5.02	Gravel		do	36,935.71	18,467.85
	27	Benson	24.04	Graded earth		Sept. 11	87,123.76	43,561.88
	35	Logan	22.06	Earth		Sept. 30	75,351.40	37,675.70
	48	Pierce	21.60	do	Sept. 29		51,700.00	25,850.00
	49	Golden Valley	19.30	do	Sept. 18		26,937.58	13,468.79
	50	Griggs	4.00	do	Sept. 20		8,030.00	4,015.00
	52	Grand Forks	.928	Concrete	Sept. 29		61,160.00	18,556.00
	53	Stark	5.50	Earth	do		11,990.00	5,995.00
	55	Stutsman	6.00	do	do		19,800.00	9,900.00
Ohio	42	Seneca	4.28	Bituminous, concrete, or brick		Sept. 12	169,000.00	42,800.00
	49	Morgan	3.257	Macadam		do	82,000.00	41,000.00
	53	Mercer	5.739	Concrete		Sept. 30	173,060.00	61,500.00
	59AB	Fayette	8.69	Macadam or bituminous		Sept. 12	206,000.00	86,900.00
	84	Cuyahoga	2.01	Concrete or bituminous	Sept. 4		190,011.00	40,200.00
	90	Jackson	2.48	Macadam	Sept. 23		43,835.00	20,000.00
	97	Noble	9.47	Concrete or macadam	Sept. 18		220,000.00	67,100.00
	98	Jefferson	2.328	Brick and concrete	Sept. 25		109,000.00	46,560.00
	101	Adams	6.16	Macadam	Sept. 20		119,000.00	48,000.00
	102	Seneca	2.03	Brick or bituminous	Sept. 29		90,000.00	20,300.00
	103	do	2.25	Asphalt or brick	Sept. 23		59,000.00	22,500.00
	105	Lucas	3.508	Concrete	Sept. 30		88,000.00	44,000.00
Oklahoma	8	Ottowa	15.63	Bituminous		Sept. 20	328,313.51	164,156.75
	14	Oklahoma	.753	Concrete		Sept. 30	26,626.10	13,313.05
Oregon	16	Wasco	2.00	Bituminous		Sept. 25	50,807.57	25,403.78
Pennsylvania	18	Clarion	5.04	Brick		Sept. 2	260,853.04	109,053.23
	20C	Adams, Cumberland, York	4.60	Concrete or bituminous		do	199,765.44	92,030.00
	30B	Bradford	2.588	Concrete		Sept. 12	133,621.84	51,760.00
	38	Crawford	3.13	Concrete or bituminous		Sept. 11	130,181.26	62,600.00
	39	Dauphin	6.397	Concrete, brick, or bituminous		do	323,155.20	127,940.00
	42	Union	2.55	Concrete or bituminous		Sept. 12	90,536.47	45,268.24
	46	Lancaster	7.137	do		Sept. 2	272,000.25	136,000.12
	47	Lycoming	7.44	Concrete		Sept. 11	355,113.78	154,279.55
	49	Dauphin	4.69	do		Sept. 20	205,549.08	93,800.00
	50	Lancaster	4.07	Concrete or bituminous		Sept. 11	178,302.23	84,360.01
	51	McKean	5.975	Concrete or brick		do	254,820.24	119,500.00
	52	Northumberland	4.81	Brick, concrete, or bituminous		do	219,589.16	96,200.00
	53	Bradford	5.944	do		Sept. 20	344,861.88	118,880.00
	54	Bucks	2.819	Bituminous or concrete		Sept. 29	123,063.10	56,380.00
	55	Butler	7.892	Brick or concrete		Sept. 30	386,357.73	157,840.00
	59	Lehigh	5.705	do		Sept. 12	263,572.21	114,100.00
	60	Somerset	7.175	do		Sept. 29	451,264.88	148,981.30
	61	do	6.065	do		Sept. 12	321,670.69	124,251.87
	62	Sullivan	3.298	Asphalt, brick, or concrete		do	168,481.15	65,960.00
	63	Susquehanna	5.745	Concrete		do	246,040.41	114,900.00
	64	Tioga	5.315	Asphalt, brick, or concrete		do	294,214.28	106,300.00
	67	York	6.201	Brick or concrete		Sept. 29	311,605.28	144,573.40
Rhode Island	5	Providence and Kent	.946	Bituminous		do	34,529.00	17,264.50
South Carolina	9	Newberry		Top soil		do	[1] 7,442.82	[1] 3,721.42
	18	Greenwood		do		do	[1] 11,044.38	[1] 5,522.19
	31	Spartanburg	1.99	Asphalt	Sept. 10		57,749.92	28,874.96
South Dakota	16	Hughes	17.83	Earth and gravel	Sept. 29		70,367.88	35,183.94
	17	Lake	12.14	Gravel	Sept. 27		73,926.60	36,963.60
	18	Hand	15.03	do	do		121,369.05	60,684.52
	19	Hyde	6.95	do	Sept. 29		60,414.75	30,207.37
Tennessee	13	Carroll	2.79	do	Sept. 10		31,951.08	15,975.54
Texas	56	Jefferson		Concrete	Sept. 18		[2] 70,928.82	[2] 59,948.42
	80	Harris	9.269	Concrete and macadam		Sept. 2	91,280.79	25,000.00
	82	Jasper	16.21	Gravel	Sept. 26		146,506.80	30,000.00
	89	Wood	10.20	do	Sept. 29		43,999.08	10,000.00
	97	Brazos	10.33	Gravel and concrete	do		99,995.62	37,752.75
	99	Calhoun	4.621	Shell	Sept. 10		13,663.32	6,500.00
	100	Rockwell	13.36	Concrete	Sept. 18		544,816.03	200,000.00
	101	Bowie	14.78	Gravel	Sept. 26		87,009.47	43,502.59
	104	Sabine	13.69	do	Sept. 19		119,087.54	35,000.00
Vermont	4	Addison		Bridge		Sept. 11	[1] 25,728.44	[1] 1,363.95
Virginia	19	Hanover and Carolina				Sept. 16	[1] 10,772.28	[1] 5,386.14
	25	Pittsylvania		Bituminous macadam		do	[1] 8,548.85	[1] 4,274.43
	31	Northampton	1.59	Concrete		Sept. 12	49,654.44	24,827.22
	49	Caroline and Spotsylvania	.30	Bridge and approaches		Sept. 19	11,569.25	5,784.62
Washington	5	Cowlitz		Graded and drained earth		Sept. 5	[1] 37,441.80	[1] 18,720.90
	14	Okanogan	[1] 5.44	Gravel		Sept. 2	[1] 45,625.79	[1] 22,881.65
	15	do	.87	do		do	31,130.82	16,780.63
	16	Stevens	13.00	do		do	168,821.25	84,410.62
	19	Jefferson	[4] 3.49	do			[3] 46,999.15	[3] 23,499.57
	20	Spokane	7.83	Gravel or macadam		Sept. 26	90,755.98	45,377.99
	21	Grant	4.88	do		Sept. 2	48,695.19	24,347.59
	22	Spokane	4.50	Concrete		Sept. 12	144,494.04	72,247.02
	23	do	3.88	do		do	128,584.28	64,292.14
	24	King	6.41	do		Sept. 29	199,292.26	99,646.13
	25	Thurston	6.83	do		Sept. 2	208,120.32	46,600.00
	26	Grays Harbor	2.90	do		do	88,366.41	44,183.20
	27	Lewis	6.70	do		do	243,863.07	121,931.53
	28	Snohomish	1.12	do		Sept. 5	35,534.09	17,767.04
	37	Douglas	2.79	Macadam		do	21,710.44	10,855.22
	41	Thurston	6.16	Gravel		Sept. 30	109,996.06	54,998.03
West Virginia	8	Wayne	1.93	Concrete		Sept. 29	91,115.62	30,000.00
	9	Jackson		do		do	[1] 13,272.53	[1] 6,193.48
	15	do		do		Sept. 20	[1] 12,959.28	[1] 6,978.00
	18	Tyler		do		Sept. 11	[1] 3,863.10	[1] 4,964.80
	33	Preston	2.52	Asphalt macadam		Sept. 16	30,000.00	15,000.00
	35	Monongalia	4.50	Concrete		Sept. 11	88,654.00	44,000.00
	43	Raleigh	1.43	Bituminous		do	17,267.97	8,600.00
	51	Wayne	3.20	Earth		Sept. 30	46,313.71	23,156.85
	53	Harrison	2.489	Brick		Sept. 20	88,265.50	38,000.00
	54	Greenbrier	1.98	Bituminous		Sept. 16	30,768.94	15,384.47

[1] Modified agreements. Amounts given are increases over those in the original agreement.

[2] Revised statement. Figures given are increases over those in the original statement.

[3] Statements previously approved withdrawn.

FEDERAL AID PROJECT APPROVALS AND AGREEMENTS IN SEPTEMBER, 1919—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approval.	Project agreement signed.	Estimated cost.	Federal aid.
West Virginia	60	Monroe	4.00	Macadam	Sept. 4		$53,800.00	$26,900.00
	61	Summers	6.00	Earth	Sept. 10		38,000.00	19,000.00
	64	Jefferson	7.37	Bituminous	Sept. 4		77,390.00	38,695.00
	65	Logan	1.30	Concrete	Sept. 23		39,380.00	19,690.00
	66	Wirt	4.48	Earth	Sept. 20		39,625.00	19,812.00
	67	Berkeley	8.00	Bituminous	do		82,840.00	41,420.00
	68	Nicholas	2.01	Earth	Sept. 10		29,229.20	14,614.60
	69	Braxton	9.60	do	Sept. 20		79,875.00	39,937.00
	70	Grant	9.00	do	do		47,200.00	23,600.00
	71	Tucker	7.00	do	Sept. 27		57,150.00	28,575.00
	72	Hampshire	8.50	do	Sept. 29		57,500.00	28,750.00
	74	Kanawha	2.60	Concrete	Sept. 27		138,585.70	51,920.00
	75	Calhoun	4.50	Earth	Sept. 30		39,050.00	19,525.00
	76	Brooks	1.00	Concrete or bituminous	do		28,800.00	14,400.00
	78	Randolph	5.75	Macadam	do		103,700.00	51,850.00
Wisconsin	10	Walworth		Concrete		Sept. 2	[1] 10,499.22	[1] 3,499.74
	45	Ashland	7.931	Earth	Sept. 18		38,999.36	12,999.78
	52	Lacrosse	1.39	Bituminous			18,007.50	6,002.50
	57	Shawano	7.70	Gravel		Sept. 12	58,493.22	19,497.74
	59	Jefferson	1.64	do		do	14,148.64	4,716.21
	71	Marathon	4.94	Earth and gravel		Sept. 11	40,851.37	13,617.12
	82	Vernon	3.28	Bituminous		do	46,370.20	15,456.73
	83	Jackson	2.57	Earth		Sept. 30	24,014.99	8,005.00
	84	Crawford	2.26	do		Sept. 20	25,116.49	8,372.16
	86	Lafayette	3.47	do		Sept. 30	40,762.44	13,587.48
	89	Polk and Burnett	8.198	do		Sept. 12	45,339.00	15,113.00
	93	Marquette	4.07	Sand-clay		Sept. 30	24,936.86	8,312.29
	95	Milwaukee		Bridge	Sept. 20		[2] 2,388.76	[2] 796.22
	98	Washburn	.568	Earth		Sept. 12	5,385.84	1,795.28
	99	Douglas and Washburn	7.04	Gravel	Sept. 10		63,000.00	21,000.00
	101	Barron	4.253	Earth	Sept. 29		44,793.77	14,931.25
	102	Waukesha	2.31	Concrete	Sept. 10		59,966.94	19,988.98
	103	Milwaukee	1.50	do	do		44,455.73	14,818.57
Wyoming	23	Niobrara		Earth		Sept. 26	23,526.91	11,763.45
	27	Weston	12.614	Earth and gravel	Sept. 30		88,000.00	44,000.00
	29	Albany	26.57	Gravel		Sept. 30	134,549.05	67,274.52
	37	Goshen	19.29	do	Sept. 27		171,734.20	85,867.10
	41	Crook		Bridge	Sept. 4		9,790.00	4,895.00
	42	Sheridan	9.323	Gravel	Sept. 30		79,970.00	39,985.00
	47	Fremont		Bridge	Sept. 29		14,300.00	7,150.00
Total	292		2,231.62				40,701,324.13	18,384,499.13

[1] Modified agreements. Amounts given are increases over those in the original agreement.
[2] Revised statement. Figures given are increases over those in the original statement.

ROAD BUILDING IN ILLINOIS.

Since last April Illinois has let contracts for over 500 miles of concrete roads of the highest type, the total cost of which will be $16,380,000. None of this work comes under the Illinois State highway program to be carried out with the funds derived from the bond issue of $60,000,000 voted last fall.

Included in the contracts are 89.44 miles of the Lincoln Highway crossing the northern part of the State from Chicago Heights to Clinton, Iowa; 59.15 miles on Dixie Highway from Chicago to Danville; 228.71 miles on the Chicago, Peoria, Springfield to St. Louis, highway; and 121.8 miles on the national highway from St. Louis to Terre Haute, Ind.

A BIG COUNTY RECORD.

In the year ending September 30, 1919, Kent County, Mich., built 189 miles of road, including 21 miles of concrete, 7.75 miles of stone macadam, 12.75 miles of stone base and gravel top and 147 miles gravel. Under the Covert law of Michigan providing for State aid to roads, contracts have been let for 30.95 miles of concrete and 6.25 miles of gravel roads. The county spent during the year $56,392 for maintenance of highways.

OHIO ROAD CONSTRUCTION.

According to State Highway Commissioner Taylor, Ohio has contracts under way covering 500 miles of road, of which the cost will be about $14,500,000. The largest mileage under contract at any time previous was 371 miles in 1916. For the two years ending June 30, 1921, the State appropriation for main market roads is $2,255,500 and for the intercounty roads $6,466,500. The automobile license fees available for maintenance and repairs will amount to about $5,000,000. The Federal aid granted for 1919 and 1920 amounts to $10,205,625. The figures make a total of $23,927,625 for the Ohio State highway system. In addition to this the expenditures for construction and maintenance of county and local roads will be large. At the recent election 66 counties voted on special local levies for road purposes.

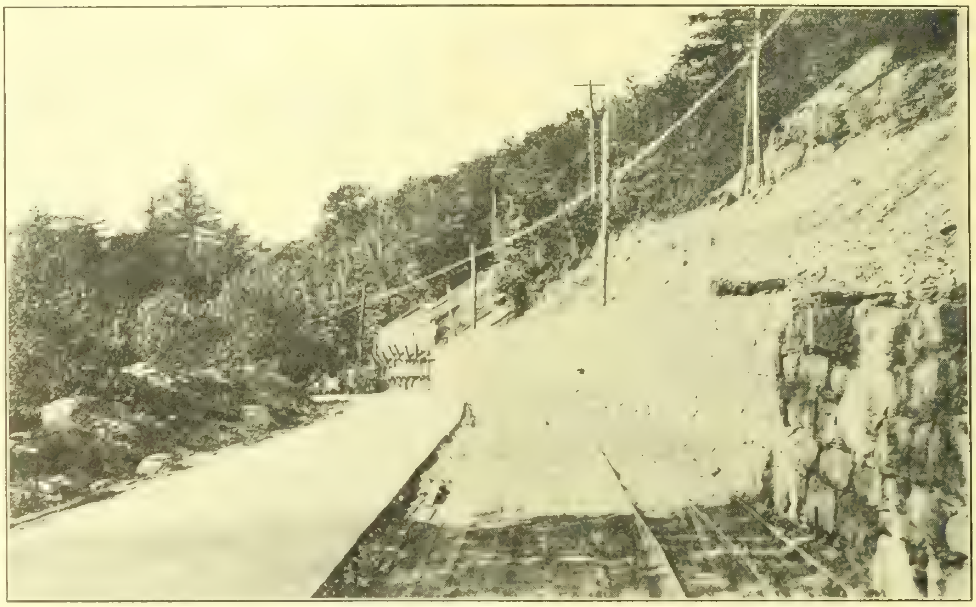
CONNECTICUT FUNDS.

The Connecticut State highway commission had made an allotment of $1,342,000 to the 147 towns of the State for the improvement of roads, exclusive of trunk lines and Federal-aid roads. To this amount the towns will appropriate $375,700.

ROADS FOR MOTOR TRUCK TRAFFIC.

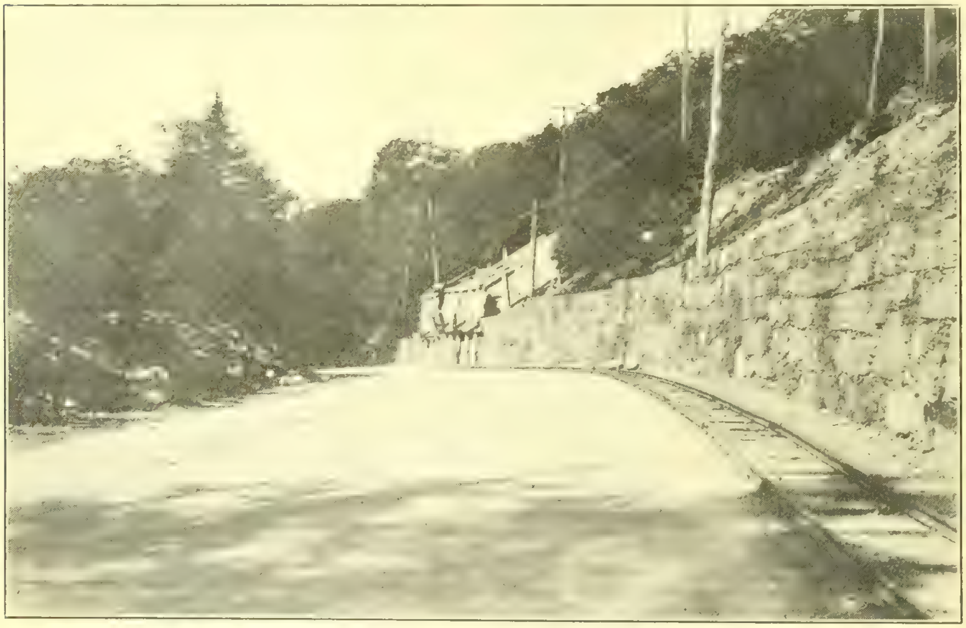
By C. J. Bennett, State Highway Commissioner, Connecticut.

IT IS hard for the highway engineer to keep step with the advance in the design of motor vehicles. No sooner does he apparently solve the problem than his friends who are in the business of producing motor vehicles develop a machine which entirely revolutionizes conditions.


CONSTRUCTION OF ROAD AT NAUGATUCK, CONN., IN TWO PARTS TO ACCOMMODATE TRAFFIC. INDUSTRIAL TRACK FOR THE DELIVERY OF MATERIAL AND STONE BINS IN THE BACKGROUND.

Generally, in the design of this vehicle, no attention is paid to the character of the road over which these units must operate. Considerable discussion could be aroused over the wisdom of designing motor trucks and motor vehicles with such a disregard for the conditions, but it is not the province of this article to originate such a discussion, chiefly because the motor truck is here, and we must redesign our roads to take care of this agency.

A discussion of the economic side of this question, as to whether it is right to design something that will take the place of railroad facilities instead of trying to improve such railroad facilities, is also beside the mark. Thus, there are many instances where, contrary to his judgment, the highway engineer is forced to change his ideas and design for traffic which up to two years ago was almost beyond imagination.


COMPLETED ROAD, NAUGATUCK, CONN., WHICH WAS CONSTRUCTED IN TWO PARTS.

HALFWAY MEASURES OF NO AVAIL.

It is the intent of this article to convince the highway engineer that he is faced with a serious problem and to show him that halfway measures will not avail for its solution. Notwithstanding restrictions as to the weight, loading, size, speed, and width of motor trucks, these will gradually increase, and there must be cooperation between the producer of these trucks and the highway engineer in order that the engineer may know the extreme limit beyond which he must not be required to go in the design of highways. This discussion will not include a discussion of road surfaces necessary for passenger-car traffic, since the road that will serve the motor truck will probably well serve the passenger automobile.

For purposes of argument, let us assume, therefore, that the extreme weight of the motor vehicle, including the load, shall be 15 tons, that its width shall not exceed 9 feet, and that its load per inch width of rubber tire shall not exceed 700 pounds. The speed of this vehicle should be restricted so that it would at all times be under reasonable control, particularly in sections where houses or buildings are close together along the borders of the highway over which the truck is to be operated.

It will be noted that the limit of weight and size has been set quite high in order to do away with any objection on that particular point from the manufacturer.

COMPLETED ROAD, NAUGATUCK VALLEY, CONN., SHOWING INDUSTRIAL TRAIN USED DURING THE CONSTRUCTION.

QUESTIONS TO BE SETTLED.

We now have a statement of our problem which gives rise to three questions:

First. What shall be the width of the road?

SECTION OF NAUGATUCK VALLEY ROAD, CONN., SHOWING THE FINISHED PAVEMENT.

Second. What shall be its character both as to surface and foundation?

Third. What shall be done with the bridges at present existing?

Answering the first question, let us assume that the motor truck is to operate over a highway traversed by a maximum of 4,000 vehicles per day. With reasonable traffic restrictions, a width of 22 feet should be sufficient for this class of traffic. This will provide for two lines of vehicles to pass in opposite directions at high speed. For any highway in which the traffic exceeds the amount stated above sufficient width should be provided for three or four lines, adding 10-foot-width units at a time for each line of vehicles.

As was stated above, no attention has been paid to the economic side of this problem or to the wisdom of building roads of this character for a selected type of traffic. What we are attempting to do is to state fairly what is necessary to accommodate the classification of traffic that already exists.

TYPE OF ROAD TO BE USED.

Answering the second question as to the type of road to be used, this question subdivides itself (*a*) as to foundation and (*b*) as to surface. With traffic of the character and magnitude specified above, great care must be taken in the foundation, both for the road itself and for the road surface. In cases of difficult soil conditions, additional foundations must be added and drainage provided to carry away the water so that the general subsurface of the road itself shall be uniform and sufficient to transmit the surface concentrated loads evenly to the earth beneath. It is evident, at least to the writer, that if the character of the traffic is as stated above, any foundation other than a monolithic foundation would be unsatisfactory; that is, no loose stone foundation will be sufficiently strong at all times to carry the loads. Consequently, the foundation for the surface must be bound together with Portland cement or with a bituminous binder. Again, it is not the purpose of this article to specify any particular method of getting results. It is merely intended to generalize and point the way to success.

(*b*) What shall be the type of road surface for this class of traffic? Here, again, we are faced with the necessity of securing a road surface which will stand impact from the passing loads and wear evenly under the stress of traffic. Consequently, no road surface should be installed for this character of traffic which does not closely approximate the surface of the highest type of city pavements which are now constructed. Such surfaces may be of brick, of concrete properly prepared, or of bituminous material, or even of granite block. In other words, in order that the roads which we build may stand the traffic to which they will probably be subjected, no pavement should be designed unless it is a hard surface pavement or can easily be tranformed into such when the necessity arises.

SELECTION OF ROUTE VITALLY IMPORTANT.

It is, of course, idle to assume that roads of this character can be built everywhere. Consequently, the selection of routes for such traffic is of vital importance, and the road construction of this type should be concentrated on these routes, and conversely the traffic itself should be required to follow the route. In other words, there should be a restriction as to the roads upon which the heavy motor trucks should operate.

Answering the third question, in consideration of the bridges, this is a serious question because we have a large investment in highway bridges which are in fairly good condition and which were never designed for such heavily loaded vehicles as we find above. Many of these bridges, especially those of shorter span can be strengthened so as to carry these excess loads. The larger, and of course most expensive bridges, cannot be expected to stand up under these strains, and must be replaced with structures designed to meet the changing conditions. The construction of such bridges will mean an enormous expenditure of money, and great care should be taken in their design, both as to selection of type and execution of the work itself. The use of reinforced concrete is strongly recommended for bridges where it is possible to design such structures, and such bridges should not be designed without careful study and the knowledge of all the factors that enter into the problem. The width of these bridges should be sufficient to accommodate at least three lines of vehicles and, on the important routes, four.

MUST MEET PROBLEM FAIRLY.

The above may appear to be a very extravagant statement of the needs of traffic at the present time, but the writer has come to believe that the motor truck is a vital part of our transportation facilities and that it has come to stay, and we must meet the problem fairly by designing for an extreme load approximating that stated above. He also believes that the motor truck manufacturer must restrict himself within the limits stated, and not attempt to exceed in any dimension the specifications made.

The motor truck operator must also use judgment in the loading and operation of these vehicles and consent to restrictions both as to dimensions and routing, so that the general public welfare may be served.

WISCONSIN COUNTY BONDS.

Five Wisconsin Counties—Jefferson, Washington, Wood, Racine, and Green—voted in September in favor of bond issues for road building, the total amounting to $11,850,000. Rock County voted a $1,500,000 issue in April, making the total for the year $13,350,000. Propositions for bond elections are being urged to come before county boards in November, aggregating $32,000,000 in these counties: Dane, $10,000,000; Grant and Dodge, $5,000,000 each; Walworth, $3,000,000; Brown and Waukesha, $2,500,000 each; and Douglas and Waupaca, $2,000,000 each.

Racine County voted in favor of the bonds by a majority of 2,038, out of a total vote of 3,962, only one township casting an adverse vote. Washington County's vote was 2,351 to 1,543, all the cities and villages but one favoring and 8 out of 14 townships voting yes. In Jefferson County the vote was 2,623 for and 1,540 against, the cities and villages favoring and the townships voting against by a majority of 178. Wood County gave a majority of 891 in a vote of 3,811, the country districts voting adversely by a small majority. In Green County the proposition for an issue of $3,000,000 was the constitutional limit. There was an active campaign, ending in a majority of 119 in a vote of 2,836.

MAINE VOTES BONDS.

On September 8 by a vote of about five to one Maine indorsed the proposal to raise the bonded indebtedness of the State for State highways from $2,000,000 to $10,000,000, giving an additional $8,000,000 to be spent on the State road system.

MOTOR VEHICLES AND THE HIGHWAYS.

By **WILLIAM D. SOHIER**, former Chairman Massachusetts Highway Commission.

ROAD building is a constant evolution, because no sooner is the improved road built to carry a vehicle of a certain weight and size than the builder of the vehicles tries to increase both the weight and size.

I personally believe that there should be a very stringent regulation and limitation on both the weight and speed, as well as the width, height, and length of the vehicles that are allowed to use our highways and bridges.

I believe, also, that if heavy trucks are to be allowed to use the highways there should be some provision for routing them, so that they can not wander at will over our little country roads, destroying bridges and culverts, and tearing up roads that are now adequate for all local traffic. If heavy trucks are to use the highways they should be confined to using the main lines only, and only such weights should be permitted as can safely use the highways and bridges that have been already constructed at great expense.

Otherwise we shall have a great many miles of road that it has taken many years to improve and build up destroyed, a great many bridges broken down, and even our main roads will be put out of commission, so that no one can use them for long periods of time.

PAST A GUIDE TO FUTURE.

In considering what traffic the highways will have to carry in the near future, we can only judge by our past experience. That the motor traffic will increase is sure. This is well shown by the following table, showing the increase in Massachusetts in motor vehicles in six years, in the number of operators, and in the fees collected.

Motor vehicles, and especially trucks, are constantly increasing.

The increase in the number of motor vehicles registered in Massachusetts indicates the increase in traffic.

	1912	1915	1918	Per cent of increase, 6 years.
Automobiles and trucks	50,132	102,633	191,019	280
Motor cycles	5,034	9,520	12,708	150
Operators and chauffeurs	65,600	133,700	225,272	240
Motor vehicle fees	$616,236	$1,235,723	$2,159,257	250

There are over three times as many automobiles and trucks registered as there were six years ago, over three times as many operators, and the fees collected are three times as large, this based on the statistics collected for 1918; and during the first nine months in 1919 over 209,000 automobiles and trucks have been registered.

FEES PAY FOR MAINTENANCE.

All the fees are spent in maintaining and improving the main highways. In fact, last year we practically maintained all our main highways with the money collected from this source.

How the truck traffic has increased is shown by the following tables:

Automobiles, trucks, and commercial vehicles, etc., in Massachusetts.

	1915	1916	1917	1918	Per cent of increase, 3 years
Trucks	12,053	18,194	25,505	32,676	171
Automobiles	90,580	118,615	145,801	158,343	75
Motor cycles	9,520	10,713	10,956	12,708	33

A large number of trucks belonging to the Government, and also trucks owned in other States, are using our roads, so that the increase in volume of truck traffic is much larger than the foregoing figures indicate.

The number of trucks and commercial vehicles registered has increased from 12,000 in 1915 to over 39,000 in 1919, more than three times as many trucks as there were three years ago.

CHANGES IN TRAFFIC.

The change that has taken place in traffic is clearly shown by the following table. This is made up from traffic counts taken every three years from 1909 to 1918. An actual count is made for 14 hours a day for 7 days in August and 7 days in October. The table which follows shows the average number of vehicles that are using our main highways, and is based upon the average count in each of these years at 44 stations on main lines.

Average daily traffic on main roads in Massachusetts.

	1909	1912	1915	1918	Per cent of increase, 9 years.
Light horse	91	68	40	24	−73½
Heavy horse	88	88	72	43	−51
Total horse	179	156	112	67	−62½
Automobiles and light trucks	131	280	555	923	+604
Heavy trucks		17	45	75	[1] +341
Total motors	131	297	600	998	+661
Total vehicles	310	453	712	1,065	+244

[1] In 6 years.

This clearly shows what is happening on our roads.

While the traffic has increased very rapidly, actually having increased over threefold in the last nine years, it is changing even more rapidly than it is increasing, and the change is even more significant from the road builder's point of view.

There were only one-third as many light horse-drawn vehicles in 1918 as there were in 1909. There were only one-half as many heavy horse-drawn vehicles.

On the other hand, the number of automobiles and light trucks using our main highways has increased sevenfold in nine years.

MOST IMPORTANT FEATURE.

But what is even more important and makes more difference in the character of road which we must build and maintain, is the increase in heavy trucks In 1909 there were practically no trucks using our roads. In 1912 there was an average of 17 a day. In 1915 there were 45 a day, and in 1918, 75 a day, the counts being made at the same stations. In other words, the number of trucks using the main highways has increased four and one-half times in six years.

The change in the traffic is perhaps even more graphically shown by the following table of percentages:

Per cent of total traffic.

	1909	1912	1915	1918
Light horse	29	15	5½	2
Heavy horse	28	19	10	4
Total horse	57	34	15½	6
Trucks		4	6½	7
Motors	43	62	78	87

It is astonishing, but true, that while horse-drawn vehicles constituted 57 per cent of all the traffic on our main highways in 1909, in 1918 the horse-drawn vehicles were only 6 per cent of the traffic, and motor vehicles, which were only 43 per cent of our traffic in 1909, were 87 per cent in 1918.

We must not forget that the total traffic using our roads has increased over threefold.

While the horse-drawn vehicles are to-day only 6 per cent of the total traffic using our highways, the heavy motor trucks—to wit, over 1 ton not on pneumatic tires—have already become 7 per cent of the total traffic.

WHAT SHOULD OUR HIGHWAYS STAND?

Perhaps even more significant is the change in the last three years. During that short period of time both the automobile traffic and the motor truck traffic has increased 66 per cent, or an increase of about 22 per cent a year.

With traffic increasing as it is, and especially the heavy truck traffic, we have now to solve the problem of whether our roads can stand such traffic, and whether they can or should be so constructed that they will not be destroyed within a very short time.

I should say that it was practically an impossibility for any rural community to furnish roads every mile of which could withstand the strain to which they are subjected—unless possibly on a few main through highways, and even on those the weights should be sufficiently limited not to destroy a highway that is of as expensive construction as the community can afford to pay for and the ordinary traffic warrants.

The weight and speed of trucks should be limited before the roads are destroyed, before highways that have cost the communities millions of dollars to build and which are entirely adequate for all the other traffic that uses the roads, are ruined, which would mean that they are of no use for any kind of traffic.

WEIGHTS MUST BE LIMITED.

Even in cities like London, experience conclusively shows that the weights to be transported over the highways must be limited, because in a great many instances 6-inch or even thicker concrete foundations have been shattered under a wood block or asphalt pavement.

It needs no argument to show that we can not afford to construct such pavements even on main lines on all of our country roads, costing, as they would to-day, from $5 to $7 a square yard (including foundation) or from $50,000 to $70,000 for an 18-foot hardened surface a mile. The cost is prohibitive on the country roads, even on main lines.

To illustrate, in New England on many main through lines the best and most expensive surface that the community can afford to build is gravel. In New Hampshire and Vermont particularly a great many miles of their main highways are of gravel except near the larger cities. Often they have to be oiled, but they are very satisfactory for the motorists who use them. More than a thousand motors on a pleasant summer day is very common.

However, if these same roads were used by a few 5-ton trucks with 5-ton loads when they were soft, the work of many years would be destroyed, and these very satisfactory motoring highways would be almost worthless.

The cost, use, and value received and paid for should be considered.

As an example—in Massachusetts we have maintained and improved every year, for several years, a main through line 26 miles long by widening, surfacing, draining, etc., using a gravel surface and oiling it and keeping it constantly patched and maintained. Every year its condition is improved.

AS TO THE COST.

This has cost less than $1,000 a mile a year, and this highway has an average traffic in summer of over 800 motors a day, with an average of about 20 trucks a day. Calling it 1,000 vehicles a day for 200 days a year, the average cost has been a half cent a vehicle a mile.

Assuming that this highway were constructed of concrete, 6 inches thick and 18 feet in width, that it would be adequate for heavy trucks and would last 20 years:

Such a highway at present prices would cost from $30,000 to $40,000 a mile to construct, including grading, drainage, etc. Assume you can borrow the money for 5 per cent on 20-year serial bonds:

The average interest, say 2½ per cent on $40,000 would be, per year	$1,000
One-twentieth of principal redeemed would be	2,000
Call the annual maintenance per mile for guardrail, shoulders, drainage, etc	100
Yearly cost of highway	3,100
Gravel road, oiled, maintained, etc., per year	1,000
Excess cost for truck road, per year	2,100

This extra yearly cost is for 1 mile of road to carry heavy trucks in addition to the lighter motors.

Assume they use the road 300 days a year. That would be $7 a day additional cost for the truck traffic.

If 20 trucks use this road daily, it would cost the community 35 cents a mile per day per truck. If 100 trucks use the road it would cost 7 cents a mile per day per truck.

WHERE THE BURDEN FALLS.

Why should the community pay this additional cost of $2,100 a mile a year to enable a few users of the highway to transport excessive loads?

The cost must be paid by someone, and heavy freight should not be transported over highways unless on the whole it is economical for the community. It is much cheaper to transport heavy weights on rails than to construct highways each and every foot of which can withstand a weight of from 10 to 15 tons on four wheels.

This gravel road to which I refer is the Newburyport Turnpike, a main line between Boston and Newburyport.

Another example in the western part of the State, the Mohawk Trail, is on the main line east and west from Boston via Fitchburg, Greenfield, North Adams, and Williamstown.

It was built over Florida Mountain with special appropriations by the legislature. Twenty-two miles of that road is situated in three towns, Charlemont, Savoy, and Florida. A part of it is constructed with a bituminous top, but probably even that is not strong enough to carry a very large number of heavy trucks heavily loaded—and by this I mean trucks in excess of 2½ or 3 tons. The rest of the road is practically a graded dirt road, kept constantly oiled and maintained. However, it adequately cares for all the present traffic, often over 1,000 motors a day.

TOO MUCH FOR LOCAL COMMUNITIES.

But before the construction of this road is completed, with a reasonably good surface sufficient for all vehicles that will use it except for vehicles in excess of 6 tons including vehicle and load, the State will spend at least $1,000,000 in the three towns mentioned, Charlemont, Savoy, and Florida.

When you consider that the total valuation of these three towns in which these 22 miles of road which will cost $1,000,000 is located is less than $1,500,000 it becomes self-evident that the local communities could not possibly construct any such road as that, much less could they construct one to carry heavy trucks at probably twice the cost.

It is costing about $750 a mile a year to maintain these 22 miles of road in these three towns. Therefore it is also self-evident that these towns can not afford to maintain a road of even the character that is there now, because it would require a tax rate of over $11 on all the property located in those towns to maintain even that one road, to say nothing of all the other roads in the towns.

TRUE OF MACADAM ROADS ALSO.

The facts I have given relating to a gravel road are also true of a vast number of the older macadam roads in this country. Massachusetts has a very large mileage of these roads built over 10 years ago. We are maintaining them, and can maintain them, with bituminous surface treatments and constant care and maintenance, for many years, to carry 1,000 vehicles or more a day at a cost of $600 to $1,000 a mile a year, even at present prices for labor and materials.

They are not strong enough, however, to withstand large numbers of 5-ton trucks with 5-ton loads. To rebuild them all in a few years is a financial impossibility. Meantime they should not be made useless because a few truck owners abuse them.

Of course, it may be entirely possible, and probably is, for some of our richer communities to build and maintain their main streets so they can withstand heavy truck traffic; I might add that they not only can afford to do this, but they can not afford not to do it.

In Massachusetts the highway commission has constructed, or helped to construct, over 2,200 miles of improved highways on main routes. To construct these of concrete, even at $30,000 a mile, would cost $66,000,000, whereas our net debt for State highways and State-aid roads is to-day under $6,000,000, many roads having been improved by cooperative work and by use of the motor vehicle fees.

URGES LIMIT OF WEIGHT.

We can not now afford to increase our expenditures tenfold, and even if we did, and after we had reconstructed these 2,200 miles of road, there would still remain 15,000 miles of country road which must be maintained as dirt or gravel roads for a good many years to come.

I do believe, however, that the main through lines, especially between large centers of population, should, when they are constructed or reconstructed, be built of a permanent form of construction and designed to carry reasonably heavy loads, but never excessive loads. There should be an absolute limit of weight beyond which the makers of motor vehicles and the users of the highways should not be allowed to go. Meantime, until they are constructed or reconstructed, the users of the highways should be restrained by law from destroying our improved roads.

TRAFFIC CENSUS SHOWS VALUE OF PAVED ROADS TO LOS ANGELES.

By JOHN C. VEENHUYSEN, Superintendent of Roads, Los Angeles County, Calif.

TRAFFIC census of our main highways has been taken ever since our road department was organized in 1914, with the main object to watch and measure the increase in traffic due to the improvement of highways as well as to the increased use of motor-driven vehicles, and to the gradual development of the country through which these roads are located. Also, the idea prevailed that it might be possible to show some fixed ratio in maintenance expenditures of paved roads with the amount of traffic they carry, but ultimate results have shown that such was not borne out by the facts—at least, not when such roads are kept in continuous repair, preventing any serious damage on account of neglecting smaller defects due to wear and tear of the traffic.

In taking up the matter of paved roads in general, we must necessarily look into their reason. Some of our roads are of general importance, as direct commercial highways, connecting densely populated centers of habitation or export and import termini, such as Los Angeles and Long Beach Harbors. Some are rural highways, where there is a well-fixed traffic of field and dairy products in a certain direction, with a variable amount of local traffic over intermediate sections of the road. Some are highways mainly used for pleasure, incidentally used for local traffic or commercial character. Some highways have a steady traffic during the whole year, especially the first-named commercial highways, whereas some have a very variable traffic, depending on seasons and crop movements.

METHOD OF TAKING THE CENSUS.

It is not possible to establish a correct average traffic over a highway of any considerable length where it is receiving traffic from feeders or where traffic is not carried over the full length of the road on account of it being crossed by secondary roads which absorb part of the traffic going or coming in a certain direction. For that reason we have established fixed points of vantage from where our census is taken for each road, and we take the exact count of vehicles passing that point for seven consecutive days in shifts of eight hours for each day. The count is taken by hours and is so segregated, in order to show the fluctuation of traffic. Standard weights have been adopted for the classes of vehicles, and these standards are very conservative and only accepted after study of the types of the various vehicles which are most commonly used. The data so collected is averaged for the seven days, as to number of vehicles and the corresponding weights. By platting the traffic curves for each road, we find that each road represents a different curve depending upon the special character of the traffic and local conditions, showing wide variation in the time of the peak of traffic on various roads and the shifting of this peak to different hours in succeeding census on the same road. Another feature is the regular, steady decrease of horse vehicles and a material increase of motor trucks as freight carriers.

FIGURES FOR FOUR HIGHWAYS.

Under following are some of our traffic data:

Harbor Boulevard, connecting Los Angeles City with San Pedro Harbor.—Macadam road, traveled width 24 feet, length 11.33 miles between city limits.—In operation since March, 1912.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automobiles.	Motor trucks.
Oct., 1914	2,857.41	237	124	910	216
Apr., 1916	2,977.66	77	110	1,265	274
Aug., 1917	4,376.12	83	118	2,598	283
Apr., 1918	5,439.83	39	169	3,542	331
Apr., 1919	6,043.41	24	102	3,600	421

Long Beach Boulevard, connecting Los Angeles City with city of Long Beach.—Macadam road, traveled width 16 feet, length 12.47 miles between city limits.—In operation since March, 1911.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automobiles.	Motor trucks.
Nov., 1914	1,933.68	69	76	1,109	121
Apr., 1916	3,213.83	24	93	1,630	206
June, 1917	2,913.31	25	85	1,966	163
July, 1918	5,176.25	28	93	3,483	267
June, 1919	8,327.30	25	92	5,682	387

Both these are principally commercial highways. Under following is a road which is principally a pleasure road, with some mixed agricultural traffic.

Washington Boulevard, connecting Los Angeles City with city of Venice.—Macadam road, traveled width 16 feet, length 9.16 miles between city limits.—In operation since July, 1911.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motor-cycles.	Automobiles.	Motor trucks.
Aug., 1915	4,105.58	54	159	2,972	108
Nov., 1916	3,753.72	97	89	2,471	96
July, 1917	6,905.71	53	188	5,341	180
May, 1919	8,832.80	41	86	6,946	196

Following is a rural road, carrying principally agricultural and dairy products, in addition to local travel from Los Angeles City to the village of Downey.

Telegraph-Laguna Road.—Macadam road, traveled width 18 feet, length 4.53 miles.—In operation since August, 1913.

Date of census.	Average traffic in tons per 24 hours.	Average daily number of vehicles traveling.			
		Horse.	Motorcycles.	Automobiles.	Motor trucks.
Dec., 1915	574.42	98	31	284	19
Dec., 1917	2,404.62	46	38	1,587	131
June, 1919	3,064.42	39	41	1,809	141

The above are samples showing traffic on roads of different character but of the same type of improvement.

THE SAVING OVER OTHER ROAD TYPES.

To determine their economic value, we figure the operative income of the road on the basis of tonnage of freight moved and miles passenger traffic. Our figures show that there is a direct saving in cost of hauling of 15 cents per ton-mile on paved roads against ordinary dirt roads, and after most careful consideration of all factors—economy in wear and tear of tires, engine and body of auto, fuel, lubricants, and especially saving in time—there is a direct saving of 2 cents per mile traveled by auto on a paved road against the ordinary dirt road, and that this saving is a very conservative average. The motor truck traffic reduced to ton-miles and the automobile traffic to miles traveled and computed on the basis of above figures of 15 cents and 2 cents, respectively, will establish the operative income of the road.

As our traffic, with rare exceptions, shows steady increase, we accept the traffic census taken as a basis for the coming year, in order to be conservative, and therefore ignore the increase during that year. Even so, our figures show remarkable results. Of above mentioned roads, the Harbor Boulevard showed for year 1918 an operative income as follows:

Horse traffic	ton miles	326,675		
Motor truck traffic	do	3,421,086		
Total	do	3,747,761	at $0.15	$562,164.10
Auto traffic	miles	14,647,763	at 0.02	292,955.26
Total				855,119.36

ECONOMIC VALUE TO THE PUBLIC.

As the cost of improving this road and maintenance since it came into operation up to January 1, 1919, has been $364,434.10, the result obtained is such that there can be no doubt whatsoever as to the economy of road improvement to the community.

The fact that this is not readily recognized by the public at large is due to the condition that this operative income does not show up in revenue, but in saving of expenses to the public without their directly realizing it. Lower cost of transportation is reflected in lower prices, economy in time of transportation brings dairy and agricultural products to the markets in fresher condition, and the public become gradually so accustomed to these conditions that they forget about it.

Road improvement as a means of development of communities and suburban districts is a factor so well known that mention is hardly necessary. Especially in the suburban rural districts in this county there has developed along these improved roads a method of disposing of agricultural products—vegetables, fruit, etc.—to the passing traffic, which has become a matter of importance and can not longer be ignored. This method of disposing of and acquiring these products is greatly appreciated by buyer and seller—the buyer acquiring them fresher and at no higher cost, and the seller disposing of them with less trouble and greater profit. It may decrease, to some extent, freight traffic but again it increases passenger traffic, and therefore becomes another factor influencing the traffic conditions on some of our principal roads.

A BIG COUNTY PROGRAM.

The supervisors of Wayne County, Mich., have in mind the construction of 350 miles of concrete highways, which would be 25 per cent of the roads outside the cities, and estimated to take care of 80 per cent of all traffic in all weathers. At the present rate of construction it would take from 12 to 15 years to build this mileage, and it has therefore been recommended that the half-mill county tax for improved highways be restored. This tax has not been levied for two years, maintenance and repairs having been cared for out of the county's share of automobile license fees. It is estimated that it will cost $1,500,000 to bring the bridges of the county up to modern requirements.

IDAHO HIGHWAY FUNDS.

So far the counties and special districts of Idaho have voted for highway bonds to the amount of about $10,000,000, and it is estimated that when the bond-voting campaign is completed the total will run up to about $15,000,000. Federal aid will add several millions to this. Most of this money will be spent in 1920.

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ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

NOTE.—Applications for the free publications in this list should be made to the Chief of the Division of Publications, U. S. Department of Agriculture, Washington, D. C. Applicants are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.

REPORTS.

Report of the Director of the Office of Public Roads for 1916.
Report of the Director of the Office of Public Roads for 1917.
Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

BULLETINS.

(In applying for these publications the name of the office as well as the number of the bulletin should be given, as "Office of Public Roads Bulletin No. 28.")

*Bul. 28. The Decomposition of the Feldspars (1907). 10c.
*37. Examination and classification of Rocks for Road Building, including Physical Properties of Rocks with Reference to Their Mineral Composition and Structure. (1911.) 15c.
*43. Highway Bridges and Culverts. (1912.) 15c.
*45. Data for Use in Designing Culverts and Short-span Bridges. (1913.) 15c.
*48. Repair and Maintenance of Highways (1913).

DEPARTMENT BULLETINS.

(In applying for these bulletins the name should be given as follows: "Department Bulletin No. 53.")

Dept. Bul. 105. Progress Report of Experiments in Dust Prevention and Road Preservation, 1913.
136. Highway Bonds.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
257. Progress Report of Experiments in Dust Prevention and Road Preservation, 1914.
*284. Construction and Maintenance of Roads and Bridges from July 1, 1913, to December 31, 1914. 10c.
347. Methods for the Determination of the Physical Properties of Road-Building Rock.
*348. Relation of Mineral Composition and Rock
370. Structure to the Physical Properties of Road Materials. 10c.
373. Brick Roads.
386. Public Road Mileage and Revenues in the Middle Atlantic States.
387. Public Road Mileage and Revenues in the Southern States.
388. Public Road Mileage and Revenues in the New England States.
389. Public Road Mileage and Revenues in the Central, Mountain, and Pacific States, 1914.
390. Public Road Mileage in the United States. A Summary.
393. Economic Surveys of County Highway Improvement.
407. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1915.
414. Convict Labor for Road Work.
463. Earth, Sand-Clay, and Gravel Roads.
532. The Expansion and Contraction of Concrete and Concrete Roads.
537. The Results of Physical Tests of Road-Building Rock in 1916, including all Compression Tests.
*555. Standard Forms for Specifications, Tests, Reports, and Methods of Sampling for Road Materials. 10c.
583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
586. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1916.
660. Highway Cost Keeping.
670. The Results of Physical Tests of Road-Building Rock in 1916.
691. Typical Specifications for Bituminous Road Materials.
704. Typical Specifications for Nonbituminous Road Materials.
724. Drainage Methods and Foundations for County Roads.

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* Department supply exhausted.

OFFICE OF PUBLIC ROADS CIRCULARS.

(In applying for these circulars the name of the office as well as the number of the circular should be given as "Office of Public Roads Circular No. 89.")

Cir. 89. Progress Report of Experiments with Dust Preventatives, 1907.
*90. Progress Report of Experiments in Dust Prevention, Road Prservation, and Road Construction, 1908. 5c.
*92. Progress Report of Experiments in Dust Prevention and Road Preservation, 1909. 5c.
*94. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1910. 5c.
98. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1911.
*99. Progress Reports of Experiments in Dust Prevention and Road Preservation, 1912. 5c.
*100. Typical Specifications for Fabrication and Erection of Steel Highway Bridges. (1913.) 5c.

OFFICE OF THE SECRETARY CIRCULARS.

Sec. Cir. *49. Motor Vehicle Registrations and Revenues, 1914. 5c.
52. State Highway Mileage and Expenditures to January 1, 1915.
59. Automobile Registrations, Licenses, and Revenues in the United States, 1915.
62. Factors of Apportionment to States under Federal Aid Road Act Appropriation for the Fiscal Year 1917.
63. State Highway Mileage and Expenditures to January 1, 1916.
65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
*72. Width of Wagon Tires Recommended for Loads of Varying Magniture on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.

FARMERS' BULLETIN.

(The Farmers' Bulletins are a series of popular treatises issued by the Department of Agriculture. The following list includes only numbers contributed by the Office of Public Roads, and should be applied for by numbers, as "Farmers' Bulletin No. 239.")

F. B. 338. Macadam Roads.
505. Benefits of Improved Roads.
597. The Road Drag.

SEPARATE REPRINTS FROM THE YEARBOOK.

(In applying for these separates the numbers should be given as "Yearbook Separate No. 638.")

Y. B. Sep. *638. State Management of Public Roads; Its Development and Trend. 5c.
727. Design of Public Roads.
739. Federal Aid to Highways.

REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

Vol. 5, No. 17, D-2. Effect of Controllable Variables Upon the Penetration Test for Asphalts and Asphalt Cements.
Vol. 5, No. 19, D-3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D-4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D-6. A New Penetration Needle.
Vol. 6, No. 6, D-8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
*Vol. 10, No. 5, D-12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction. 15c.
Vol. 10, No. 7, D-13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D-15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.
Vol. 17, No. 4, D-16. Ultramicroscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

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* Department supply exhausted.

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U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 20 WASHINGTON, D. C. DECEMBER, 1919

SUNSET ON THE LACKAWANNA TRAIL, PENNSYLVANIA

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in the planning or construction of highways, instructors in highway engineering, periodicals upon an exchange basis and Members of both Houses of Congress. Others desiring to obtain "Public Roads" can do so by sending 15 cents for a single number to the Superintendent of Documents, Government Printing Office, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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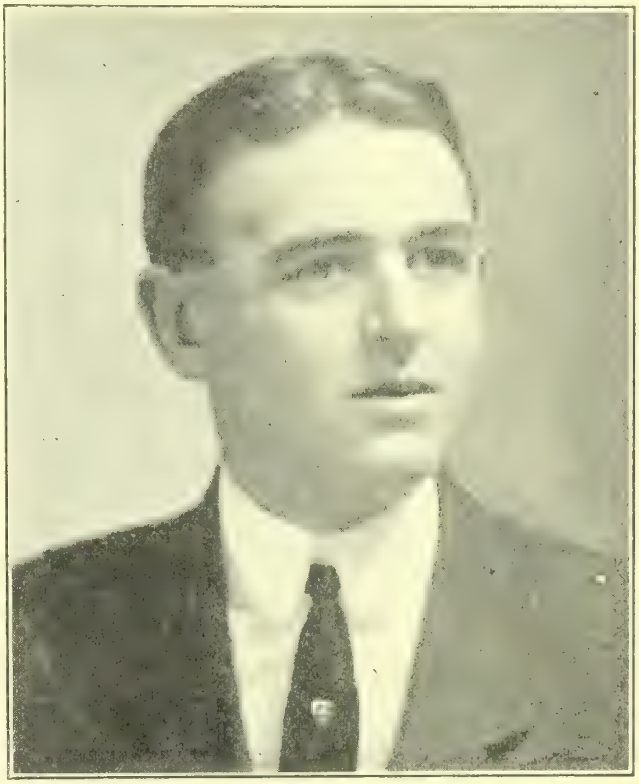
PAPERS AND DISCUSSIONS AT THE HIGHWAY OFFICIALS' CONVENTION.

THE annual convention of the American Association of State Highway Officials, held at Louisville, Ky., December 8–11, 1919, was very largely attended and was one of the most important in the history of the association. The subjects discussed and the resolutions adopted bore directly upon the problems affecting the road building activities of the country and especially upon the carrying out of the present extensive program of highway construction.

Because of the importance of the meeting and the various subjects discussed Public Roads presents to its readers just as complete a report of the papers and discussions as is possible. The length of the program and the variety of topics makes it necessary to devote two issues to the convention. It has not been found possible to print every paper in full, but there has been as little condensation as possible.

It has been necessary to give, in most cases, only the more important ideas and facts brought out in the discussions.

Resolutions adopted by the convention were as follows:



A. R. HIRST, PRESIDENT.

PARTICIPATION OF PUBLIC LAND STATES IN FEDERAL AID.

Whereas, The Federal aid road act provides for financial cooperation between the States and the Federal Government whereby the Government may contribute not more than 50 per cent of the cost of any Federal aid project; and

Whereas, This basis of cooperation is manifestly unfair to the so-called public land States, where vast areas exist in which the titles still rest in the Government, and such lands are not subject to taxation by said States; and

Whereas, On this account said States in many cases are unable to raise the funds necessary to meet the Government on a 50–50 basis, and thus complete their main trunk-line roads which are an integral part of the interstate road system; therefore, be it

Resolved, By the Association of State Highway Officials in convention assembled at Louisville, Ky., on December 11, 1919, that the factors determining the total allotments of Federal aid moneys to each State, as now fixed by law, be not disturbed; however, in determining the percentage of cooperation required of each public land State, the following plan should be followed:

The percentage which the patented land area bears to the total area of such State, shall be determined by the Secretary of Agriculture, the 50 per cent now required as such State's portion of cooperation shall be multiplied by the resultant percentage as above determined, and the figure obtained will be the minimum percentage which such State shall be required to furnish of the total of any Federal aid project.

Be it further resolved, That nothing in the above resolution shall prevent any public land State from participating in a larger percentage than that above determined, on any Federal aid project.

Be it further resolved, That this new basis of cooperation in public land States may apply to projects, now under project agreement, between such States and the Government, and on any project agreements that may hereafter be entered into between the same.

Be it further resolved, That a copy of these resolutions be addressed to the Senators and Representatives in Congress at the earliest possible moment, and that a copy be addressed to the honorable Chief of Bureau of Public Roads, and that legislation be urged at the present term of Congress to put the above provisions into effect.

REVISION OF SALARIES.

Whereas, The Federal and State Governments of our country have entered upon a program of improving the highways of the nation on a scale that makes this the greatest engineering project ever undertaken in the history of the world, at a cost to the taxpayers of many billions of dollars in the next decade; and

Whereas, To expend these vast sums efficiently and without waste, to get a dollar's worth of road for every dollar of tax, most urgently demands that the best engineering executive talent of the country be drawn into this work at once; and

Whereas, In order to draw the best talent into this work our State and National Governments must offer conditions of employment much more favorable than generally prevail at present both in the line of financial reward, in the permanency of the positions offered, and in freedom from political interference; and

Whereas, Wise provision for the future demands that the financial rewards offered should be such as to attract the best young men in the engineering colleges to prepare themselves for a life work in highway engineering; and

Whereas, A policy of niggardliness in this matter is one that can only bring disaster and waste in this great undertaking, and is, therefore, the most short-sighted economy.

Be resolved, By this association of State highway officials in convention assembled at Louisville, Ky., December 11, 1919, that our executive committee be instructed to present these facts with every proper urgency to the President and the Congress of the United States, and to the governors and legislative bodies of each State as soon as next they are in session; and that the executive committee be instructed to call to the attention of the various executives and legislative bodies and impress upon them the necessity of revising the salaries of engineers upward in substantial accordance with the appended schedule and impress upon them that provision for its adoption is a measure of wisest public economy.

RECOMMENDATIONS FOR SALARIES FOR ENGINEERS IN STATE HIGHWAY SERVICE.

Administrative and executive positions.

Chief engineer	$8,000	$15,000
Engineer of construction	6,000	10,000
Engineer of maintenance	6,000	10,000
Engineer of bridges	5,000	8,000
Office engineer	5,000	8,000
Engineer of tests	4,000	7,000
District engineer	5,000	8,000

Senior engineering positions involving some administrative duties in the higher grades.

Advisory and consulting engineer to the chief engineer	$5,000	$10,000
First assistant engineer	3,600	5,000
First assistant bridge engineer	3,600	5,000
Assistant construction engineer	2,400	4,000
Assistant maintenance engineer	2,400	4,000
Assistant bridge engineer	2,400	4,000
Assistant office engineer	2,400	4,000
Chief chemist	3,500	5,000
Assistant division engineer	2,400	4,000
Assistant testing engineer	2,400	4,000
Assistant chemists	2,000	4,000
Chief draftsmen	2,400	4,000
Chiefs of survey parties	2,400	4,000

Inspection service.

Confidential inspectors	$4,000	$5,000
General inspectors of maintenance	2,400	4,000
Inspectors of bridge construction	2,400	4,000
Field inspector of materials	2,400	4,000
Inspectors of construction	2,400	3,000
Inspectors not employed in working season, per month	250	300

Junior engineering positions concerned with routine work only.

Engineering, draftsman, computers, checkers	$1,800	$2,400
Computers, checkers	1,800	2,400
Engineer draftsmen	1,800	2,400
Instrument men	1,800	2,400
Instrument men employed, per month	200	250
Rodmen, chainmen, and tracers	1,200	1,500
Laboratory assistants	1,800	2,400

THANKS TO MR. A. N. JOHNSON.

Resolved, That the thanks of the American Association of State Highway Officials be extended to Mr. A. N. Johnson. of Chicago, for the presentation of his paper on "A Proposed Scale of Salaries for All Classes of Highway Engineers in Public Service."

IN RE CONFERENCE WITH ASSOCIATED GENERAL CONTRACTORS.

Be it resolved, By the American Association of State Highway Officials, in convention assembled at Louisville, Kentucky, December 11, 1919, that its executive committee appoint a subcommittee to confer with a committee appointed by the associated general contractors to discuss matters of mutual interest and importance, and that the report of the conference be sent to the various State highway departments.

IN RE INTERNATIONAL ASSOCIATION OF ROAD CONGRESSES.

Resolved, That the American Association of State Highway Officials, in convention assembled at Louisville, Kentucky, December 11, 1919, through its executive committee, urge on the Congress, the importance of taking the necessary steps for the United States to become a Government member of the International Association of Road Congresses, and that appropriation be made therefore,

Resolved further, That his action be taken at once in order that necessary arrangements may be made for holding the next meeting of the international congress (May, 1921) in this country.

THANKS TO THE HOTEL SEELBACH.

Be it resolved, That the American Association of State Highway Officials, express to the management of the Hotel Seelbach its appreciation of the many courtesies extended to both the association and the individual members during the convention assembled at Louisville, Kentucky, December 8th to 11th, 1919, and,

Be it further resolved, That the secretary of the association be requested to mail to the Hotel Seelbach a copy of this resolution.

THANKS TO LOUISVILLE CONVENTION AND PUBLICITY LEAGUE.

Resolved, That the secretary be instructed to extend to the Louisville Convention and Publicity League and its managing director, Mr. T. R. Maas, the thanks of the Association of State Highway Officials for the hospitality and pleasant features which they have provided during our meeting in their city.

AMENDMENT TO ABOLISH HONORARY MEMBERSHIP.

Whereas, The American Association of State Highway Officials was organized for the purpose of providing mutual cooperation and assistance to the State highway departments of the several States and Federal Government, as well as for the discussion of legislative, economic, and technical subjects pertaining to the administration of such departments; and,

Whereas, Many of the subjects to be discussed are of more or less confidential or personal nature and relate only to the affairs of one or more of the departments forming the association:

Therefore, be it resolved, By the American Association of State Highway Officials in convention assembled at Louisville, Kentucky, December 11, 1919, that the constitution and by-laws be so amended that honorary membership in the association be abolished and the meetings of the association be open only to such persons as are eligible for full membership, provided, however, that the program committee appointed to prepare the program for any meeting may, with the approval of the president, extend to persons not eligible for membership, special invitation to attend such meeting and address the association on some specific subject, or such persons as may be invited by the executive committee or association in session.

KAHN BILL, DISTRIBUTION OF WAR SUPPLIES.

Whereas, The War Department has an abundance of surplus war materials, equipment, and supplies, including motor vehicles, suitable for use in highway construction, and

Whereas, The Secretary of War has authority under the provisions of section 7 of the Post-Office appropriation act to transfer such surplus war material, equipment, and supplies to the Department of Agriculture for distribution to the highway departments of the various States, and,

Whereas, The Secretary of War is disposing of and offering for disposition said war materials, equipment, and supplies instead of making the transfer to the Department of Agriculture as authorized and contemplated by law, and,

Whereas, Economic returns to the people would be greater if the surplus material were used in highway construction than if sold at private sales,

Be it resolved, That it is the sense of the American Association of State Highway Officials in convention assembled at Louisville, Ky., on December 11, 1919, that H. B. 9412, generally referred to as the Kahn bill, including the amendments recommended in a letter written by Mr. Thomas H. McDonald, Chief of the Bureau of Public Roads, dated September 20, 1919, and which appears as a part of the record of the hearing on the Kahn bill before the House Military Affairs Committee, be immediately enacted into law and made effective, and,

Be it further resolved, That copies of this resolution be transmitted immediately to the House of Representatives of the United States.

KAHN BILL.

Be it resolved, That it is the sense of the American Association of State Highway Officials in convention assembled at Louisville, Ky., December 11, 1919, that the State highway department of each State be requested to call upon influential citizens of their respective States to urge upon their congressional delegation the immediate passage of H. R. 9412 and the amendments recommended by Mr. Thomas H. McDonald, Chief of Bureau of Public Roads, in a letter dated September 20, 1919, and addressed to the Secretary of the War Department.

ADVOCATING TOPOGRAPHIC MAPS.

Whereas, The vast program of highway construction now undertaken by the Federal and State Governments has great need of adequate topographic maps such as the Federal Government is now making, and,

Whereas, These maps are now completed for only a small part of the area of the country, and,

Whereas, The saving in the expenditure of the highway funds, intrusted to our supervision, if these maps are made available for our use will be much greater than the cost of making these topographic maps, and,

Whereas, At a conference recently held in Washington between the various Federal and State agencies interested, a plan was developed whereby the whole country could be completely mapped by 1932 by proper cooperation between the State and the Federal Governments,

Be it resolved, By the Association of State Highway Officials in convention assembled at Louisville, Ky., December 11, 1919, that our executive committee be instructed to bring this matter to the attention of the President and Congress of the United States and the governors and legislative bodies of our respective States, and urge upon them as a measure of economy that the Federal

Government provide adequately for completing the topographic map of the United States by 1932, by appropriating the necessary sums to the Coast and Geodetic Survey and the Geological Survey; and that the State governments likewise be urged for the same reasons to provide for paying their share of the cost; and be it further

Resolved, That the executive committee be instructed to appoint a special committee whose duty it shall be to carry forward the work.

OPEN-TOP CARS.

Whereas, The Federal Congress and the legislative bodies of the several States have made available for highway construction during the years 1920 and 1921, funds generally exceeding appropriations made for previous years; and,

Whereas, If these increased appropriations are to be efficiently and economically expended, adequate transportation facilities must be provided for the delivery of road-building materials; and,

Whereas, During the past working season the supply of open-top cars available for the hauling of road aggregates was far short of the requirements for the carrying out of the road program of 1919 and if the number of open-top cars is not materially increased there will be a still greater shortage which will prevent the carrying out of the proposed program for the coming year; Therefore

Be it resolved, That the American Association of State Highway Officials in convention assembled at Louisville, Ky., December 11, 1919, hereby directs its executive committee to use every means possible to impress upon Congress the necessity for making provision for an adequate number of open-top cars to be added to the equipment of the several railroad lines before the beginning of the next construction season.

PUBLIC LANDS AND APPROPRIATION.

Whereas the States within whose boundaries are included large National Forest reserves have expended, during the last five years, millions of dollars in the improvement of State and county highway systems and;

Whereas the majority of these States have issued bonds in large amounts in order to finance modern highway construction; and

Whereas there are within the boundaries of these States approximately 150,000,000 acres of National Forest reserves; and

Whereas State and county highways of national importance traverse these reserves through areas involving the most difficult construction in the West; and

Whereas the forests are a great national asset which should be preserved, and the construction of roads traversing them facilitates the control of forest fires which have in the past caused tremendous losses; and

Whereas the amount involved in road construction would represent but a small percentage of the value of the timber resources which could be preserved from destruction by fire, and the value of such national timber resources would be greatly increased by reason of the construction of an adequate highway system through and adjacent to the National Forests; and

Whereas appropriations heretofore made by Congress have been inadequate to permit of sufficient road construction, within the National Forests, to keep pace with State and county highway systems or to provide for a standard of construction equal to that of the several States and counties; and

Whereas the withdrawal of large areas has decreased the taxable resources of such States and counties, and has also operated to reduce their bonding capacity; and

Whereas it is the duty of the National Government to provide sufficient funds to develop its national resources according to the same rate and standards as that of the States and counties concerned. Now, therefore, be it

Resolved, That the American Association of State Highway Officials, in convention assembled at Louisville, Ky., on December 11, 1919, urge upon Congress the necessity of appropriating at least $10,000,000 per year for the next 10 years, at least 75 per cent of which would be for expenditure in the construction of primary State and county highway systems within and adjacent to the National Forests.

Whereas most of the conditions hereinbefore stated apply also to Indian and other Federal reservations and to reserve and unappropriated lands of the United States. Now, therefore, be it

Resolved, That the American Association of State Highway Officials in convention assembled at Louisville, Ky., on December 11, 1919, urge upon Congress the necessity of appropriation of at least $2,500,000 for the fiscal year ending June 30, 1921, and thereafter $5,000,000 per year for the next nine years, for the purpose of constructing highways in said areas.

Further resolved, That copies of this resolution be transmitted to the House of Representatives and United States Senate, and that the highway department of each State be requested to urge upon its congressional delegations the passage of suitable bills making such appropriations available.

FEDERAL AID APPROPRIATIONS.

Whereas there have been introduced in Congress various bills contemplating or affecting Federal participation in highway work, which bills represent a wide divergence of policies; and

Whereas we believe that it is necessary that Congress should take action on this matter during the present session in order to enable the States to more completely outline their program of highway building; now, therefore,

Be it resolved, by the Association of State Highway Officials in convention assembled at Louisville, Ky., on December 11, 1919:

1. That we urge the continuance of Federal operation with the States in the building of roads under the terms of existing law and under the direction of present agencies. To this end we recommend and urge that Congress appropriate the following sums:

The sum of $100,000,000 for the fiscal year ending June 30, 1921.
The sum of $100,000,000 for the fiscal year ending June 30, 1922.
The sum of $100,000,000 for the fiscal year ending June 30, 1923.
The sum of $100,000,000 for the fiscal year ending June 30, 1924.

2. That all of said appropriation allotted to the several States shall be available for said States until one year after the expiration of the last appropriation.

3. That we favor an adequate national highway system upon which the Federal aid funds will be concentrated. This system shall be selected by the various States in cooperation with the Bureau of Public Roads, and connected at the State lines by the Federal department in cases where connections are not made by the adjoining States.

4. Realizing that the improvement of a system of national highways will be brought about in much shorter time through the cooperation of the Federal Government and the States under the plan proposed by this resolution, we favor the passage at this time of only such appropriations as will insure the continuation of the Federal aid as provided for in this resolution.

5. That a copy of this statement be sent to each Member of Congress.

ASSOCIATION OFFICERS FOR 1920.

The American Association of State Highway Officials at the Louisville meeting elected the following officers:

President, Paul D. Sargent, chief engineer, Maine State highway commission;

Vice president, W. S. Keller, State highway engineer, Alabama;

Secretary, Joseph Hyde Pratt, State highway commission, North Carolina;

Treasurer, J. H. Mullen, deputy State highway commissioner, Minnesota;

Executive committee:

- Thos. H. MacDonald, chief, Bureau of Public Roads, 1924;
- Geo. E. Johnson, State engineer, Nebraska, 1924;
- A. B. Fletcher, State highway engineer, California, 1924;
- S. E. Bradt, superintendent of highways, Illinois, 1922;
- E. R. Neel, State highway engineer, Georgia, 1921.

Members of the executive committee whose terms hold over are Geo. P. Coleman, chairman, State highway commissioner, Virginia; W. G. Thompson, State highway engineer, New Jersey, 1923; Ira R. Browning, State road engineer, Utah, 1923; W. D. Uhler, chief engineer, State highway department, Pennsylvania, 1921; W. F. Cocke, assistant State highway commissioner, Virginia, 1921; C. J. Bennett, State highway commissioner, Connecticut, 1921.

The American Highway Problem.

A. R. Hirst, President American Association of State Highway Officials.

We commence to-day, in this our annual meeting, what I sincerely feel is the most momentous highway gathering ever held in America. For the past few years the overwhelming shadow of the World war has hung over all our deliberations. Everything else was so secondary to the issues fought for and won in that great struggle that even those of us who most implicitly believed in the importance of highway work in America felt that highways and work upon them should be subordinated to the other and greater world purposes.

We did, however, fight and fight successfully in order that the great highway movement be not utterly crushed in the midst of the manifold demands of war, because we felt that by keeping together the nucleus of a highway organization, despite many short-sighted attacks, we were doing the American people a real service. It was not pleasant work, nor profitable, to those of us who were in the midst of the storm. But it was worth while, and the fight was won, even though for a time the production of ukuleles was ruled by the powers that be as more important than the production of highways.

THE NEW ERA.

But now all is changed. The American people, almost as one man, are demanding, and that instantly, a modern and comprehensive system of highways and are willing to pay the price. They have at last realized that the price of building highways which will serve the needs of the present and of the logically-to-be-expected traffic is far less than the price they must pay if the present embargo of mud continues. Never, I believe, since the days of early railroad development have the American people been so determined to change instantly their means of transport and not even then were they so willing to pay the cost, provided they could get the results.

What are the results they are now demanding and what are some of the problems that grow from these demands?

They are expecting the States which had no highway organizations three or even two years ago, which had done no preliminary work and in some of which hardly a mile of modern rural highway had ever been built, to create an organization full sprung from the earth (like our imaginary defensive and aggressive army was to spring) and to build instantly hundreds of miles of modern roads costing millions upon millions of dollars. In the older States in the highway game, better prepared with organizations and contractors, and with some knowledge of materials and construction conditions, they are asking us to double, triple, or quadruple our annual output of roads. It is probably fair to estimate that the expenditure for modern highways in rural America in 1919 was about $200,000,000, and that the sum desired to be expended for them in 1920 exceeds $600,000,000. In other words, the people of America desire to approximately triple their highway expenditures and to do it in one year.

We are wont to think of the era of railroad building in America as presenting the greatest of engineering problems and that its solution was an astounding exhibition of the capacity of American engineering genius. However, the problem confronting American highway engineers to-day far exceeds the old one in magnitude. In the record five years of railroad development (1879 to 1883, inclusive) there were built 40,000 miles of railroad costing, as nearly as I can ascertain, about $20,000 a mile on the average, or $800,000,000 in all. In the five years from 1920 to 1925, inclusive, the American highway engineer will be expected to build probably 100,000 miles of highway costing not less than $3,000,000,000. Even allowing for the depreciated dollar, the yardage of earth to be moved, the amount of materials to be furnished and transported, and the labor required is probably at least double that required in the former enterprise.

It may be of interest to list some of the tremendous problems facing the executives of State highway departments in this work of speeding up the national highway program to meet the American demand.

THE PROBLEM OF TRAINED ENGINEERING HELP.

This is a problem largely for American educators, but with the present shortage and the very restricted output of young engineers, due to the war, it is an acute one demanding immediate attention. I might add that, in my opinion, a four-year course is longer than is necessary for the preparation of much of the help that is needed, and a solution should be sought along the lines of the winter short courses of our agricultural colleges. We must have hundreds, yes thousands, of trained men at the earliest possible date and four or five years hence will not do.

MATERIALS OF CONSTRUCTION.

Nothing is more certain than that there will be an acute shortage of materials in 1920 and thereafter, unless there is substituted in place of the present hit and miss methods an intensive study of all available road materials in every State, and unless the most strenuous methods are used to develop every available source of supply. The extensive production and delivery of road materials during the winter season is going to be necessary, especially in the northern States with short construction seasons. Every State must establish a road materials department, the sole function of which will be to locate, test, develop, and arrange for the proper delivery of all available materials. Already there are rumors of combinations of material men to purchase and control all sources of highway materials. It is up to the States to protect their people by getting sufficient material sources in State and county hands before it is too late.

THE PROBLEM OF CEMENT.

It seems obvious that much, if not all of the so-called permanent surfacing will be either cement concrete or other surfacings on a cement concrete base, and that practically all drainage structures will be built of concrete. Unless there can be had the most absolute and fair Federal control of the price of cement the bidding between municipalities and States and between contractors for cement is apt to drive the price up to the point of impossibility. In lack of Federal control, the erection or purchase by the States of cement mills or State control of the output of certain mills would seem to be only a rudimentary conception of the duty of protecting the public against unduly inflated prices. The present unfair arrangement between manufacturers and dealers whereby dealers who never see or handle the cement must be paid hundreds of dollars for every mile of road built of concrete or with a concrete base must also be controlled effectively. States which buy millions of barrels of cement annually and pay always (no bad accounts) must get at least the dealer's price.

PROBLEM OF CAR SERVICE.

Car service has been execrable on practically every railroad. We have been handicapped day after day and month after month by the neglect of the present railroad officials to recognize the fact that highway building is a great American industry. If construction is to be carried on with materials delivered by rail, better car service and, in the Northern States, a longer season for shipments is necessary. Possibly the time will soon return when freight revenues will mean something to American railroads and when it will not be an insult to a railroad man to offer his company freight business. I sincerely hope so. Until then we ought not depend on materials involving a railroad haul except where no other source of supply is humanly possible. If the railroads are allowed to come out of their present state of coma and will give us the proper type of cars, enough of them, and reasonable service at fair prices in the installation of unloading sidings conveniently near the work, their revenues can be very materially increased, our costs decreased, and our work speeded up.

CONSTRUCTION ORGANIZATIONS AND PRICES.

The contracting problem we always have with us. We need every competent highway builder available and we need to immediately multiply his number two to five times in the various States. We must encourage those good contractors who are now available and develop many new ones. To do this good prices will have to be paid and fair treatment given. On the other hand, we must not hand over our clients' pocketbooks to the contractors with the injunction "take what you think is right, but please return us the cover." Unless some restraint is exercised, with the amount of work there is to be done and with the universal feeling existing that "my road must be built no matter what it costs," prices will be driven up and up without regard to proper cost, values, or profits.

In this connection it is my belief that each State should immediately develop a moderately large construction organization fully equipped to do a portion of all classes of its work. Then in case prices on certain work are extortionate, the work may be done by force account. This plan has the advantage of developing and training the nucleus of a larger day-labor organization, if one should later prove necessary. It also gives at all times a true index of the cost of various kinds of work on the basis of actual and recent State experience.

Every State has availed itself, I believe, of the offer of war equipment from the Federal Government. Large supplies of many things useful in highway work, especially motor trucks, have been or will be received. The organization of a proper department to receive, fit for use, and handle this equipment is no mean problem. The States should carefully consider whether this equipment should not be made the basis of building up a permanent thoroughly well-equipped day-labor organization as a means of protecting itself now and in the years to come.

I also believe it necessary for adjoining States to cooperate with a view of keeping prices for work fair and uniform under the same conditions. If adjoining States are going to bid against each other the cost of work in all of them will be sent up to the prohibitive point without any ultimate advantage to any State. It should be possible for the States to get together on this matter. Costs are quite figurable for each job and with a uniform system of allowances for the use of machinery, profits, and contingencies it should be possible to put work in all States on an approximately equal basis of attractiveness. These allowances must be generous, because we must attract the best contractors, but they need not, and should not, be wasteful. This problem is the most acute of all our problems and should be given immediate and serious attention by every State. I can think of no way in which more millions can be unnecessarily spent in the next few years than by allowing unbridled and useless competition for contractors and materials to prevail between municipalities.

THE PROBLEM OF LABOR.

We speak blithely of millions of dollars for the construction of thousands of miles of road. This program means men, far more men than have ever been employed in this work before. But men are scarce, and other productive labor must not be raided. Our farms, our mines, our factories, and our mills must be allowed to produce largely and at a reasonable cost. We should not pay our labor, or allow such prices to contractors as will enable them to pay their labor, a sum per day greatly in excess of the going wage for like work in that vicinity. Whether we pay high prices for labor or whether the contractor does, it is our responsibility, because the prices we pay for work determines the prices which can be paid for labor. In other words, we must not bull the labor market to the disadvantage of other production. This is public work, its continuance depends upon the support of the whole public, and we must be careful not to alienate this support by forcing our work at undue prices, thus upsetting local labor situations. This policy is not only right from the standpoint of expediency, but is also economically sound.

IMPROVED LOCATION AND ALIGNMENT.

We have, in the past, been too prone to build along the old established lines of highways. This has been the easy course and it has been taken. But the new traffic conditions are so different and so intense that in considering the construction of a main trunk highway all of the old governing considerations, such as saving the buying of new lands for right of way, utilizing old cuts and fills, saving an existing bridge or a few good culverts no longer bind us to the old locations. We must connect the centers of population because they are the points from which things and persons come and to which they wish to go. In building a modern highway between these fixed points we can feel free to exercise our untrammeled judgment and build where the road will ultimately cost the public the least. Shortness of distance, freedom from dangerous curves and from railroad grade crossings, and reasonable grades are now the principal ends to be sought and practically nothing else counts.

Cost of construction has become secondary. If the very conservative sum of 10 cents per mile is allowed for each mile of travel saved, the saving of a mile in distance on highways carrying the following average number of vehicles per day will save the traveling public the given amount per year, which is the interest at 5 per cent on the amount given in the third column.

VALUE OF A MILE IN HIGHWAY DISTANCE SAVED.

Average number of vehicles per day	Saving to owners per year.	Saving capitalized at 5 per cent.
100	$3,650	$73,000
250	9,125	182,500
500	18,250	365,000
750	27,375	547,500
1,000	36,500	730,000
2,000	73,000	1,460,000
5,000	182,500	3,650,000
10,000	365,000	7,300,000

I believe that these figures are unassailable and that they demonstrate that when building our main highways for all years to come, saving in distance in the layouts is the supreme consideration and should be given much more attention.

SOME OTHER IMPORTANT PROBLEMS.

Many other important problems could be named and briefly commented on but this paper will be too long if continued along these lines. I can not, however, resist naming without comment some of the other things with which an efficient State highway department must also concern itself.

A proper system of records of the cost of all construction and of accounting for all funds available.

Proper publicity of plans and results, not only in the local press, but in the national press.

Proper care of traffic during reconstruction.

Proper touring maps for the information of the people of the State and of other States.

Proper marking of the main traveled roads, keyed to the State maps.

Proper accommodations for the traveling public in the way of garages, hotels, public parking places, and comfort stations.

Complete knowledge and study of, and, if necessary, the design of labor and time saving devices and equipment.

A study of plant layouts and equipment for various types of construction under varying conditions.

A study of the grade crossing situation and a strong campaign for improved conditions.

The holding of road schools and short courses for the instruction and inspiration of all classes engaged in supervising and constructing highways.

Helping to formulate and pass adequate highway legislation so that the State may keep pace with other States.

THE COMING BATTLE.

It may readily be seen from this hasty survey of some of the attendant problems that these changed highway conditions and this spirit of getting hitherto unheard-of results have, instead of making our task easier, but served to tremendously increase our problems and responsibilities. We are on the threshold of a new epoch in highway construction in America, but instead of congratulating ourselves to-day that the long fight for highways is won, we should rather gird our loins for the impending battle. Added responsibilities bring added fears to the executive who thinks and spur him on to new efforts and new devices for developing himself and his organization to meet the new conditions.

The coming battle is all the more serious because from time immemorial the American people, while always willing to pay the price for the work they desire, have never been willing to pay the price of the proper supervision of it. "Millions for public works, but a pittance for those who must design and supervise the building of them" seems to be the American spirit. Our National and State legislative halls are filled with men who appropriate millions and tens of millions with very little thought of the organizations necessary to properly expend them, and with much less desire to provide proper supervision than to further the prestige of themselves or of their political party.

FEDERAL POLICY.

As a case in point: It was with the greatest difficulty that the present Congress could be induced to fix the salary of the very competent present head of the Federal Bureau of Roads at $6,000 a year, although this bureau will in the years 1919 to 1922, inclusive, supervise from the Federal standpoint and protect the Federal interest in the expenditure of probably two hundred millions of Federal money and with it the expenditure of three hundred millions more from the States and local units. The National Congress is probably the most niggardly employer in America, unless some of the States bear off the unenviable palm. It seems hopeless to expect a continuously efficient organization in any Federal bureau unless Congress shall see a new light and fix public salaries to fit the imposed responsibilities.

It is interesting, although disconcerting, to note the almost total lack of interest on the part of road-promoting organizations in the fundamental problem of getting proper administrative bodies to control the highway programs. We have good-roads associations, trail associations, highway councils, etc., ad infinitum, all seeking to promote the construction of roads in detail or in mass, and urging the Nation, the States, and the counties to spend millions or billions on highways of all kinds, classes, sorts, and conditions.

The sole idea seems to be to get money and more money to build highways. It does not appear to matter to them what kind of highways, who builds them, or whether the people get a dollar's worth or a dime's worth for a dollar. Men are in these associations who make millions every year, who control organizations which are solely designed to get efficient dollar-for-dollar results, and who pay their executives what they are worth. Yet when they get into the field of public service they seemingly forget all the rules which made their own business a success, and expect a thousand-dollar man to be the eighth wonder of the world and world-beating organizations to grow overnight with no possible financial encouragement. Unless business men of this class wake up and devote more thought to the basic problem of getting efficient organizations to spend the money, I fear a real disaster to our highway programs.

POLITICS AND SALARIES.

All of us have probably in the past derided the possibility of getting effective results out of town and county highway efforts because (we said) politics had too great a part in road work in those units and that they would never pay the salaries necessary to get competent planning and supervision of the work. And yet in 34 of the 48 States which now have State highway departments, the Governor may change the personnel of the State highway department so as to control it during his term of office. In many of these States the highway law is deliberately so framed that a new governor may make a clean sweep of the State highway department the minute he assumes office, if he so desires. In most cases he seems to have desired it. There have been at least 127 different executive highway officials in these 34 politically organized State highway departments in the grand total of 296 years of their existence, or a change every 2⅓ years (on an average) in each State. The oldest executive officer in charge of highway work in any American State has served his State 9 years in that capacity.

A State highway department is not right or it is not wrong just because it has a Republican or a Democrat at its head, or because one brand of Republican or Democrat is in control when another brand of the same political party comes into power. A State highway department is right when it is well organized to get efficient and economical results and is wrong when it is organized or unorganized to produce inefficient and uneconomical results.

Let us consider the salaries paid the executive officers of the State highway departments. There is one who is paid $20,000 per annum; two, $10,000; one, $8,000; two, $7,000; two, $6,000; and eight, $5,000, while 32 of them are paid less than $5,000 and 20 of them receive $3,600 or less. In this connection it should be remembered that the highway work expected to be supervised by a State highway department is now in few cases less than $3,000,000 a year and in many States it has reached, or will soon reach, as much as $15,000,000, $20,000,000, or $25,000,000. What business organization in the world would pay on a similar scale for similar responsibilities or would expect to receive adequate results under such conditions?

I speak of these matters not in a spirit of fault finding, but in order to interest you in the great problem of building up public opinion to the point where, for its own protection, it will insist upon the proper organization of every agency which deals with the expenditure of these great aggregations of highway funds.

CLEAN-CUT EFFICIENCY.

We must, by every means in our power, by precept and example, preach the doctrine of clean-cut business efficiency in American highway administration. In doing so we will go up against the age-long prejudice of the American people against paying their public servants a living or a proper wage. From top to bottom the scale of public salaries is wrong. The constitutional and other officers of the Nation, of the States, of the counties, and of all other municipalities are, practically without exception, being paid not on the basis of what their services are or should be worth, but on a basis fixed (in most cases long years ago) with due regard to the "honor" which must accrue to the holder of a public office.

There is or should be an honor in being selected for public service—and worthy public servants appreciate and feel that honor. It may be, although I doubt it, worth while for the American people to consistently penalize those who work for them by paying them less than a living wage or less than the work would command if done for a corporation, or if done for the individual citizen in his private capacity. But the trouble with the system is that when the American people have before them a piece of really constructive work, like their present highway program, the policy falls down absolutely.

We must help the American people by making them realize that with hundreds of millions, even billions, to be expended in the next few years the building of highways is a profession and a business and not a political football to be kicked around like the proverbial pup. This is not selfishness. Most of us are in this highway business because we love the work and because we want to help build up the States and the Nation. I doubt if there is one man here who has made good or who is capable of making good who can not leave his present State position and make more money working for himself or in employment in commercial lines. But the work must go on well and we must feel an interest above a mere financial interest in the jobs we hold, if we are worthy of them. * * *

I trust that nothing I have said in regard to State highway organizations will be wrongly construed. The present organizations, with very few exceptions, are, and have been doing effective work with limited opportunities. Where there is trouble it is in most cases due principally to the political obsession of our American Commonwealths. * * *

In fairness to my home State, Wisconsin, it should be stated that we have a nonpolitical highway commission, the operations of which have been entirely free from political interference by the governor or anyone else. I state this because there may be some idea that my remarks originate from dissatisfaction with conditions in my own State, which is not the case. Conditions, laws, and public sentiment there are good and improving fast. * * *

The professions of highway engineering and of highway building must be dignified so that they attract the best engineers and the best construction men in America. This is important, not only for the immediate future, but especially so for the years to come. Not only must we strive to attract and keep the best we have but we must get the coming men. We need all the brains and all the talent we can muster. To attract the best young men good working conditions, a clean atmosphere in public service, adequate compensation, and a reasonable chance of advancement must be offered. Less than this will not serve.

Let us dedicate ourselves to this work of helping to make all highway organizations efficient instruments, able and competent to carry out the American purpose of building a highway system befitting the greatness of the American nation. Than this, we can do the American people no greater service

INTEREST OF BONDS TOO LOW.

California is finding it difficult to dispose of highway bonds on account of the low rate of interest, 4½ per cent, fixed by legislative enactment. In November the State offered the last $3,000,000 of the second $15,000,000 issue authorized some time ago, but there was not a single bid. The first sale under the $40,000,000 issue voted last year is scheduled for an early date, but officials think the sale extremely doubtful.

Survey of Southern States Highway Situation.

W. S. Keller, State Highway Engineer of Alabama.

JUST what States should be included in this report is doubtful. I have not attempted to communicate with all really Southern States, concluding that several such States are included in the territory assigned to others. Questionnaires were mailed to North Carolina, South Carolina, Tennessee, Arkansas, Louisiana, Mississippi, Florida, Georgia, and Alabama. Replies were received from all of the States with the exception of North Carolina and Louisiana, and on the basis of these replies, I am able to give you the following information.

CONSTRUCTION AND EXPENDITURE, 1919.

Arkansas.—This mileage and cost can not be divided upon a yearly basis.

Georgia.—Two hundred miles constructed with an expenditure of $2,500,000.

South Carolina.—Ninety miles, with two bridges completed and five other bridges under construction. Total estimated cost for work done this year, about $1,100,000.

Tennessee.—Federal aid, 67.8 miles, cost, $854,837; State aid, 38.66 miles, cost, $209,153.30; total, 106.46 miles, cost $1,063,990.30.

Alabama.—One hundred miles, $600,000.

As a large number of contracts extend from one year into the next and are in various stages of construction it is manifestly impossible for a State to give accurate approximation of miles of road constructed and expenditures for the year.

PRICES AND SUPPLIES OF LABOR AND MATERIALS, 1919.

Arkansas.—Prices very high for both labor and materials; freight rates high. Labor scarce and inefficient.

Georgia.—Convict labor scarce. Free labor plentiful at $3.50 per day. Materials plentiful at source of supply but scarce and expensive because of lack of transportation and high freight rates.

South Carolina.—Prices about two and one-quarter times those of 1916.

Tennessee.—Materials satisfactory. Labor and transportation the problems.

Alabama.—Prices very high with labor hard to get and very unsatisfactory.

NEW OR PROPOSED STATE LEGISLATION.

Arkansas.—The 1919 legislature in regular and special session created special road improvement districts to build more than 6,000 miles of good roads.

Georgia.—An act of the Georgia Legislature, approved August 18, 1919, reorganizing the State highway department; and an act approved August 16, 1919, amending "Georgia motor vehicle law," which will provide approximately $2,000,000 per annum for highway construction and to liquidate the bonded indebtedness which, by vote of the people of Georgia, may be created to build and maintain roads of this State.

W. S. KELLER

South Carolina.—Proposed doubling of auto tax which will raise about $1,250,000 and a 2-mill tax which would raise about $750,000.

Tennessee.—None.

Alabama.—A new State highway law was passed by the legislature in September enlarging the power and authority of the State highway commission and increasing the State appropriation. There was also passed a bill authorizing a vote of the people, election to be held next February, to amend the State constitution so that $25,000,000 in State road bonds may be issued. If passed favorably the law becomes self-acting and will be put into effect immediately.

BOND ISSUES PASSED AND PENDING.

Arkansas.—No State or county bonds can be voted in Arkansas.

Georgia.—Counties have voted $17,000,000 in bonds. An issue of $40,000,000 in bonds by the State is pending.

South Carolina.—No State bond issues. Previous county and township bond issues total about

$7,250,000, proposed county bond issues about $3,000,000.

Tennessee.—County bond issues $11,832,250.

Alabama.—One county has voted a bond issue of $150,000, the proceeds to be used in conjunction with State and Federal aid. A constitutional provision prevents any county from having a bonded indebtedness greater than 3½ per cent of its tax valuation. Most of the Alabama counties are up to this small debt limit.

CONSTRUCTION AND EXPENDITURES 1920.

Arkansas.—See answers above.

Georgia.—Proposed mileage of construction in 1920, 400 miles with an approximate expenditure of $6,000,000.

South Carolina.—Four hundred miles and about $4,000,000.

Tennessee.—189 miles bituminous road, at $25,000, $4,725,000; 427 miles waterbound macadam, at $16,500, $7,045,500; total, 616 miles at $11,770,500. All under survey will be in shape for contract by spring.

Alabama.—If bond issue fails $1,000,000 will be spent. If bond issue is successful the expenditure will be $2,000,000. These amounts are exclusive of Federal and county funds.

1920 LABOR AND MATERIALS PRICES AND SUPPLIES.

Arkansas.—In view of large amount of work contemplated, scarcity of contractors and men, car shortage, lack of local materials, etc., prices will probably remain high.

Georgia.—It is anticipated that convict labor will diminish. Price of free labor and materials will remain the same, but supply will be deficient.

South Carolina.—About the same as 1919. No material change anticipated.

Tennessee.—Situation as to labor and material very discouraging.

Alabama.—No change anticipated.

WHAT THE REPLIES SHOW.

The information gathered from these five States establishes the following facts which can not be disputed:

1. That the South is awake to the necessity for the construction of high-class roads.

2. That despite the enormous increase in the cost of road-building materials and labor, funds are being provided and road construction is decidedly on the increase.

3. That if the enormous amount of work proposed by some of the States for the year 1920 is advertised to the world the psychological effect will greatly increase prices. It would appear that an underestimate of work to be done is decidedly better than an overestimate.

4. That road construction is no longer the sole duty of counties, but with the generous aid of the Government, the States are assuming their share of such duty.

Highway Situation in the Pacific Coast States.

Herbert Nunn, State Highway Engineer of Oregon.

The Pacific coast is only particularly interested in one National highway; that is the Pacific Coast Highway extending from California to Oregon and Washington. This when completed will have an approximate length of some 1,400 miles, and the large part of it is now completed or nearing completion.

Mr. Fletcher, of California, stated to me this morning his State had completed 525 miles, extending from Los Angeles north to Sacramento, and we are now under contract to complete the road. Oregon now has under contract on this road some 400 miles of construction, all of which will be completed by the middle of next year, 200 miles of which will be paved and the rest macadam or gravel. Washington has completed this road to Seattle, and next year its entire length will be complete.

I am unable to say at this time just how much money was expended during the year 1919 in the three States, but in Oregon approximately $7,000,000 was expended. The three States, however, are pretty well fixed financially.

California has a new bond issue for $40,000,000 and previously has expended some $33,000,000. Oregon has some $32,000,000 available and roads to cost $19,000,000 to $20,000,000 under construction. Washington has less money. They failed to carry the bond issue there this year, but have between $8,000,000 and $9,000,000 available for next year.

The eastern connections with the Pacific Highway are the Santa Fe Trail, the Lincoln Highway, and the Midland Road. I think the Santa Fe is pretty well cared for. It connects with Southern California. In Oregon we are connecting with the Southern Highway and with the Columbia River Highway.

Labor conditions on the Pacific coast are about the same as in the East. The pay is about $4.50 with $7.50 for teams. We don't expect better labor conditions next year. Material conditions are better. In Oregon we have sufficient local material and don't require much rail transportation. Washington is fixed similarly. So is Northern California. Southern California is in worse condition as to transportation.

New England Road Conditions, 1919 and 1920.

Col. Wm. D. Sohier, formerly chairman Massachusetts Highway Commission.

THE New England States, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, have an area of about 62,000 square miles, or a little more than 2 per cent of the area of the United States. They are quite thickly populated and have developed large industries.

New England contains over 7 per cent of the population, and over 10 per cent of the entire valuation of the United States, with only 2 per cent of the area. It has over 87,000 miles of rural highways, nearly 4 per cent of the total in the United States, or about twice the average number of miles of rural highway for each square mile of territory.

IMPROVED HIGHWAYS.

The New England States, especially Connecticut and Massachusetts, were among the very first to adopt a State-highway or State-aid system. As a matter of fact, I believe that New Jersey was the only other State to begin a comprenensive State or State-aid system of improved highways 26 or 27 years ago. The results accomplished in New England show clearly the advantages of such a system.

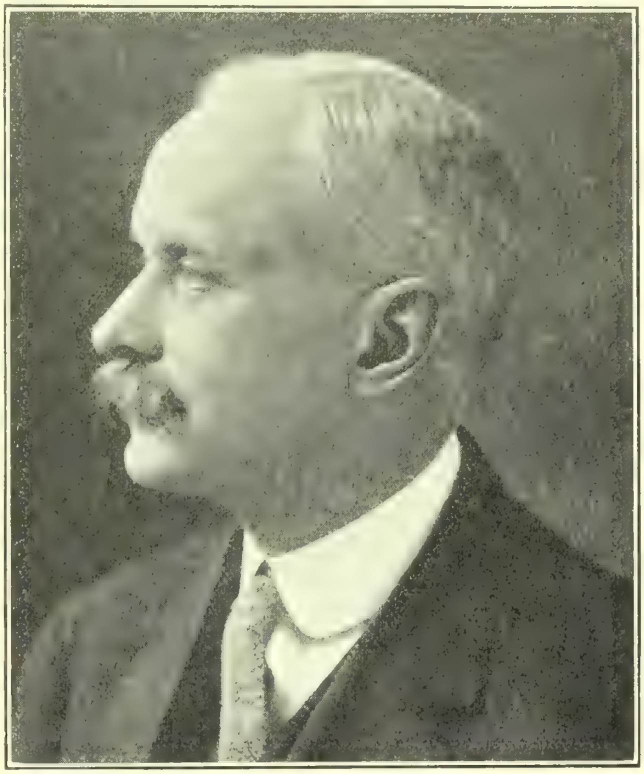
I am using the figures published by the United States Bureau of Public Roads, to January 1, 1917, allowing for recent improvements. Out of about 75,000 miles of improved rural highways in the United States, maintained under the State or State-aid system, 11,589 miles, or 15½ per cent, were in New England. Nearly one-half of these highways were in Connecticut and Massachusetts.

There were in the United States about 69,000 miles of highway which had been constructed under the State or State-aid system, and of these more than 9,000 miles, or 13 per cent were in New England. (I believe the figures published by the department are only rural highways and exclude improved highways and streets in cities, towns, and villages.)

It is stated that there are 287,000 miles of rural highway that have been surfaced in the United States. More than 40,000 miles of these, or about 14 per cent, are in New England. If city, town, and village streets were added, the mileage would be much larger.

MILEAGE OF IMPROVED HIGHWAY.

In 1916 we found that there were over 23,000 miles of highway in Massachusetts, and that about one-half of them were improved roads or streets; to wit—roads that had been graded, drained, and had material brought in to build the road. Most of these were constructed with a gravel surface or of some stronger material.



WILLIAM D. SOHIER

Since those statistics were made in my home State, Massachusetts, the mileage of road improved as State highway or State-aid road has increased from 1,100 miles credited to us by the Government, to over 2,400 miles of improved highway that is maintained. I believe some of our neighboring States have done as well or even better.

The conditions are quite different in the six New England States. The three northern States, Maine, New Hampshire, and Vermont, are, to a great extent, agricultural and lumbering States, although they have also great attractions for summer residents and tourists. With the exception of relatively a few miles on the main trunk lines, their highways do not have any large bulk of heavy traffic.

The other three States, Massachusetts, Rhode Island and Connecticut, on the other hand—while there is considerable farming in Massachusetts and Connecticut, and quite a little intensive farming in Rhode Island—are in the main, manufacturing States, are very thickly populated, and their roads carry very heavy traffic. The highways in these States are also used on through routes to the seaboard from the interior, and have had to carry a considerable amount of trucking for the Army. These last three States can afford to spend very much more per mile of road, both in construction and maintenance, than the northern States.

Most of the improved highways in the three northern States are, and must be, constructed of local materials, being very largely gravel roads or improved dirt roads. The main trunk lines in Massachusettes, Rhode Island, and Connecticut have been very largely constructed during the last 20 to 25 years, starting, originally with some gravel and a great many miles of waterbound macadam road, continuing bituminous macadam and concrete.

The traffic on these roads has very largely increased year by year on account of the manufacturing and especially because of the war activities. The roads have had to be considerably widened; many of them have had to be resurfaced. It has been found everywhere there was heavy truck traffic that a 14 to 16 foot width of hardened surface was insufficient on main highways; that at least 18 feet was necessary or it sheared off on the edges.

It has been found that waterbound macadam roads or roads with surface treatments will not, unless upon unusually good soil or foundation, withstand heavy trucks and truck traffic, especially when the frost is coming out of the ground in the spring.

THE HIGHWAY RECORD OF 1919.

During the year 1919 there were approximately 300 miles of State highway constructed in the New England States, at a cost of about $2,300,000, and 225 miles of State-aid road constructed at a cost of about $2,700,000. I could not secure accurate figures for all the States.

There were approximately 15,500 miles of road maintained by the States or under State supervision, either State highways or State-aid roads. I have not the figures for Connecticut, but $4,300,000 was spent on this maintenance and reconstruction work in the other five States.

I have not the number of men employed in all the States, but there were 515 employed in Maine, and from 300 to 600 a day in Massachusetts not including 400 town employees who actually did maintenance work.

The figures I secured are shown in the following table:

State.	1919			
	Miles maintenance.	Cost of maintenance and reconstruction.	Miles of State highway and State-aid constructed.	Cost.
Maine	4,400	$700,000	145	$1,500,000
New Hampshire	1,425	750,000	120	...
Vermont	1,518	98,670	115	412,000
Massachusetts:				
State Highway and State aid	2,286	2,211,000	...	...
73 towns	4,000	225,000	140	2,400,000
Rhode Island	333	1,000,000	...	...
Connecticut	1,627	...	...	...
Total	15,589	4,984,670	520	4,312,000

Maine has voted 5 to 1 in favor of authorizing the State to issue $8,000,000 in bonds to be used in constructing State highways and State-aid roads, also to meet Federal aid of which she secures $2,648,000.

AVAILABLE FUNDS AND WORK IN 1920.

I am showing the amounts probably to be available in the various States during 1920 (the amount available in Connecticut is given as for two years, 1920 and 1921, this including Government aid, $9,640,000 for construction and maintenance; I have divided that amount to get an average for one year):

State.	Miles of State highway construction and reconstruction.	Cost.	Miles maintenance.	Cost.
Maine	150	$4,500,000	4,500	$800,000
State aid	100-125	1,250,000	...	...
New Hampshire	100	1,250,000	1,500	750,000
Vermont	75	1,323,000	1,518	98,670
Massachusetts:				
State highway and Federal aid	100-125	3,300,000	2,286	1,200,000
State aid	100	1,500,000	...	...
Reconstruction	60	1,250,000	...	...
Poor town roads	...	...	5,500	450,000
Rhode Island	30-40	1,300,000	333	350,000
Connecticut, average 2 years	[1] 140	3,845,000	1,627	...
	855-915	19,518,000	17,264	3,648,670

[1] Estimated.

PROGRESS IN MASSACHUSETTS.

In Massachusetts under an act passed two years ago, the highway commission was authorized to aid the poorer towns of under $3,000,000 valuation, to maintain and improve their rural highways. This work has only commenced.

The State gives to the towns from the motor vehicle fees, $50 a mile a year, and the town appropriates an average of a 3-mill tax to go with the State's money—all the money to be spent under the supervision of the State engineers. Last year the legislature made available from the motor vehicle fees $200,000, and the towns had to appropriate about $100,000 to go with it.

Work was done in 73 towns and 4,000 miles of road were dragged. Next year we have asked for an appropriation of $300,000, and we think the towns will probably have to put up $150,000 for the work and that this maintenance work will cover about 5,500 miles of road.

This is the greatest advance in road improvement that we have undertaken in Massachusetts, and it promises most splendid results within a few years when the towns are properly grouped and proper machinery is secured, the plan being that a number of towns may be grouped and use the same machinery, the laborers also working in a number of adjoining towns.

It is expected that within a very few years the State will be helping over 160 towns, containing over

8,000 miles of road, to improve their roads, and maintain them, all the work being done under the supervision of the State, and that at that time the commission will have available at least $500,000 a year for the work, and the towns in which the work is done will have to make available $500,000, or about $1,000,000 in all for this maintenance work.

Certainly at the end of five years, if the present program is carried out, there will be 3,500 miles of State highway and State-aid road on the main routes in the rural districts which will have been constructed in a permanent way and be constantly maintained. There will be 8,000 miles more of dirt and gravel country road, well drained and constantly maintained and many miles of it oiled on the main lines, making about 11,500 miles of road constantly maintained in the country districts, or 67 per cent of the total of 17,000 miles in the whole State of Massachusetts. Of course, you must realize that a good many miles of this 17,000 are merely bypaths and wood roads, although they are called public highways.

CREDIT DUE MAINE FOR IMPROVED ROADS.

I wish at this point to say a word for Maine, because I think Maine and its State highway commissioners have accomplished so much in Maine during the last 6 years, including the terribly difficult period of the war.

Some of the other New England States started sometime ago, and they have been at it ever since. Connecticut and Massachusetts began 27 years ago; Rhode Island had a State highway system constructed and improved at least 5 years ago. New Hampshire and Vermont have been at work for a good many years on their trunk-line systems and State-aid roads.

Maine, however, until 6 years ago, had practically no road system whatever. As you know, during the war, particularly the last year of the war, conditions were extremely difficult. Consider, then, what Maine has accomplished during these 6 years. She made a new start in 1913 with a State highway commission and State engineer. Since that time she has constructed 391 miles of State highway, 1,393 miles of State-aid road, and several miles under special acts, the total constructed mileage being 7 per cent of the entire mileage of road in the State. She has expended for construction, $3,231,000 for State highways, and $3,242,000 for State-aid roads.

And what is more significant than this: Starting only 6 years ago, Maine, with a total mileage of over 25,500 miles of road, has now under maintenance 1,400 miles of State highways and about 3,000 miles of State-aid road.

In 1914 they were maintaining under State supervision 688 miles of road. In 1919 they were maintaining over 4,500 miles under more than 500 patrolmen, and 88 more miles maintained that were not under patrol.

NEW ENGLAND CONSTRUCTION 1920.

During the year 1920 we expect to construct about 900 miles of improved highway in New England at an expenditure of over $9,500,000. Much more important than this is the fact that we shall have, under State-supervised maintenance, over 42 per cent or more than 17,000 miles of the total of 40,000 miles of improved and surfaced highway in the country districts. We shall have available for this maintenance over $4,500,000, if I include my estimate of the expenditures in Connecticut.

We are much prouder in New England of what we have accomplished in establishing a patrol system or the constant maintenance of our highways, than we are of all the miles that we have constructed since the beginning.

Construction is easy, involves but few miles, few years, few places in any one year; but maintenance—that is different—is constantly with us year after year, day by day, and every day and every minute of the day.

The Situation in the Middle Atlantic States.

Samuel Knopf, Assistant Engineer, Delaware State Highway Department.

REPORTS from highway departments of the Middle Atlantic States, comprising New York, New Jersey, Pennsylvania, Delaware, and Maryland, indicate a total mileage of highways under construction during the calendar year 1919 of approximately 1,900 miles. The moneys expended to carry on this work amounts to a sum of nearly $75,000,000. This total is made up of the actual cash expenditures for such items as labor, materials, supervision, and administration directly connected with the construction, improvement, and upkeep of the public roads and bridges outside the limits of incorporated towns and cities, and does not include any items for the sinking fund payments or the redemption and interest on road and bridge bonds.

Of all kinds of construction undertaken in these States during the year, either public or semipublic, no work resumed operations so quickly or on so large a scale as the highway work.

THE STIMULUS TO ROAD BUILDING.

This new impetus of road building, attributed to the tremendous development and increase of the heavy motor truck to a great degree, is a by-product of the war. During the war the almost complete paralysis of railroad facilities by war-time transportation stimulated the use of motor trucks on public highways. Particularly has this been true in the Middle Atlantic States, where the production of war materials was largely centered, and through which passed nearly all troops, materials, and equipment for war purposes. In this district their increase, due to their successful operation in spite of the bad roads and weather conditions, has been little short of phenomenal, and they are to be found wherever traffic conditions permit their profitable use.

Very few of our present roads were designed to carry this class of traffic. In many places, the damage due to the incessant pounding of these fast and heavy vehicles was so great that the cost of adequate maintenance overbalanced the bond charges required for complete reconstruction. New and unforseen problems in road building had to be solved.

It is significant that the road building program of 1919 in these States was enlarged and designed primarily to cope with this traffic. The money for the construction program was immediately available, and with few exceptions, work began in full swing. Indications pointed to great records in construction. To date, with the working season over, only approximately 40 per cent of this program is completed. Failure to complete the program has been primarily due to labor conditions, shortage of materials, brought about by lack of equipment available for transportation, and a poor working season due to bad weather.

DELAY FROM LABOR CONDITIONS.

Labor conditions in this district were never more unsatisfactory. It was first thought labor would be plentiful owing to the fact that our soldiers now returning from war would be more than ample to carry on road work. Sympathetic propaganda urging that the soldiers be given first preference was spread broadcast. As the returned soldier did not take kindly to this kind of work, labor obtained to carry on road work in this district was recruited largely from foreigners formerly engaged as munition workers. Accustomed to a higher rate of pay during the war, they became restless when they were obliged to accept wages averaging 45 cents per hour. Their war savings made regular employment unnecessary. During the year in certain districts of Pennsylvania and New Jersey, thousands of this class of labor migrated to Europe. This had quite an effect on the visible amount of common labor available for road work. Contractors and others engaged on road work did not anticipate this instability of labor. In some localities, there was not sufficient labor to carry on road work under construction and the other business of the vicinity. An actual shortage existed. In other localities, labor was plentiful, but disinclined to work regularly. As the season progressed labor became more unreliable. Some contractors imported labor from cities 75 miles distant. As an instance of this drifting labor: On one job 2½ miles long, requiring an outfit of 50 men, which was completed in about three months, an examination of the payroll showed it to contain at least 500 different names. This labor turnover, besides delaying the progress of the work, influenced bidding prices and quality of workmanship.

THE SHORTAGE OF SUPPLIES.

Relative to supplies of materials, an actual shortage existed. Plants supplying materials were confronted with a large production program, larger than they had anticipated. With no chance to provide additional equipment, with labor uncertain as in other lines, and with present equipment in bad shape due to wear and tear of war work they could not keep up production. Part of the time this was due to lack of transportation facilities, but, generally speaking, to an actual shortage, or the fact that the territory was, so to speak, "overjobbed."

Equipment for transportation was in bad shape. This directly affected the actual supply of materials. Even now, there is a distinct shortage of cars for the movement of coal, drain and other commodities, which are being given first preference when any emergency arises. This condition became so acute during the last few months of the working season that it almost put a stop to the construction program. Contrary to expectations, material prices did not drop. It was thought that with the war over there would be a gradual decline, but the unusual demand for the limited supply of materials coupled with the high cost of production and the supply of transportation facilities kept prices within narrow limits—actually there was a general increase in prices of all materials.

A poor working season was experienced by all engaged on road work during the past year. Particularly has this been true in this district. The average number of working days fit for laying roadway were as follows: May, 11 days; June, 19 days; July, 19 days; August, 15 days; September, 20 days; October, 11 days; November, 12 days.

Usually the number of working days per month will average 22 days. Although this delayed the progress of the work, it helped the material shortage by making the situation seem better than it was actually.

The lateness and hesitancy of awarding some of the contracts naturally delayed the program. Contractors looking for prospective work marked time, and did not arrange for needed plant. Consequently equipment orders piled up as the season progressed and deliveries came too late for the working season.

That all these factors have had an influence in the bids submitted for road work let out late in the season, is shown by the fact that in some instances these bids received ranged 10 to 15 per cent higher than those submitted earlier, when every indication then pointed to "straight sailing" road building.

During the year legislation affecting highways was passed in several of the States. These laws affected the weights and tonnage carried by motor trucks and the use of traction engines on improved highways. Their use upon improved types of roads have been restricted. Others passed were headlight laws modifications and ones requiring all vehicles to carry lights. New legislation, empowering her highway commissioner to acquire land containing stone for road building purposes, has been passed in Pennsylvania. This stone may be used by the State or furnished and sold to contractors engaged on highway contracts under the State's jurisdiction.

THE YEAR'S GREAT PROGRAM.

The magnitude of the highway program did not become apparent until the early part of 1919, when the State and county governments began to make provisions for road funds to an extent before unknown.

Besides the annual revenue derived by taxation for road purposes, bond issues authorized or pending and other sources of money in the States were as follows:

Pennsylvania:
    $50,000,000 in State bond issues authorized.
    $17,000,000 in county bond issues authorized.
    $8,500,000 in county bond issues proposed.
New Jersey:
    $5,000,000 in State bond issues authorized.
    $1,000,000 in county bond issues authorized.
    $4,500,000 in county bond issues pending.
New York:
    $12,000,000 of the bond issue of 1912 authorized.
    County bond issues approximately $7,500,000 authorized, with a proposed State bond issue to be introduced to the legislature for $100,000,000.
Delaware:
    $2,000,000 in State bond issues authorized.
    $1,750,000 county bond issues authorized.
    $1,500,000 private fund.
Maryland:
    Program was carried on by State appropriations.
    No State bonds have been passed or pending.

To these amounts of money must be added the considerable increase of funds available under the Federal aid act and the Post Office appropriations act, which provided an additional appropriation for Federal cooperation in the improvement of rural post and forest roads during 1919, 1920 and 1921. The money allotted to these five States under these acts amounts to $32,400,000, of which $5,500,000 was applied to road building during 1919.

Notwithstanding the fact that this year's road building program has been a disappointment, preparation for road building for 1920 is even larger than that undertaken this year.

The program calls for the construction of about 2,100 miles of hard-surfaced highways, at an expenditure in the neighborhood of $100,000,000. Just what amount of this will be completed is problematical. Funds will not be the limiting factor. The limiting factors will be the same as those which held back this year's construction, namely, the amount of labor and materials available, including the ability of getting the materials on the ground, and the lack of experienced and fully equipped contractors' organizations.

WHAT THE 1920 PROGRAM MEANS.

The program to be carried out requires the moving of 12,500,000 tons of aggregates, which include the tonnage required to complete the projects carried over from this year's work. To this also must be added the tonnage of aggregates required in the resumption of building operations, railroad improvements, street work, maintenance of roads, etc., which has been seriously curtailed during the war and the year of 1919 waiting for a decrease in prices. Realizing that no decrease in prices is probable, and, because of the urgent demand for these improvements, it is safe to predict that they will be made. It is evident that a material shortage will exist unless some means are taken to improve the situation.

To successfully meet this tremendous demand for materials, transportation facilities must be improved, plant capacities enlarged, and production increased. Each is supplementary to the other. The development of one without the corresponding development of the others would tend to increase rather than to minimize a difficult situation.

The fact that materials producers were unable to secure transportation for their capacity production this year has led them to curtail their output as a means of self-protection. The coal shortage is also at present closing down some plants. As an instance, in the Lehigh Valley districts supplying cement to these States, there is nominally on hand 15,000,000 barrels of cement in stock. Reports indicate that now there are but 2,000,000 barrels on hand. Shortage of coal has closed down several of the plants, and the others are running below capacity. How serious a factor this coal crisis will become is not apparent, but is a general indication that production will be lower and prices higher.

The labor condition existing in this country is at a critical stage. Although labor seems plentiful, there is nothing in the present situation to indicate that it will be more efficient or more willing to work next year than this year, and, unless there is a full resumption of united effort, there is no chance for a larger production. Until the unorganized common laborer on road work realizes that he is no longer employed on "war work," and that no "war profits" and "war wages" exist in honest road building, he will always remain the same unreliable workman. Not until he has spent his war savings will he become more efficient. Any increase in wages does not seem to remedy the position. During the past year increases to common labor were given to help rush the program, but the general effects with regards to production remained the same. Contractors to cope with this labor are turning favorably to labor-saving devices, and wherever men can be replaced by machines the chances are they will.

COOPERATION TO COPE WITH CRISIS.

Industrial managers and concerns have begun to realize that to cope with this crisis more efficient cooperation between all parties is necessary. It is apparent that there must be the greatest degree of cooperation between the contractors, the highway department officials, material producers, and the railroads, if delivery of materials to carry on this huge construction program is to be possible. Labor for the road work and existing transportation facilities must be employed in the most efficient manner.

To this end the Delaware highway department has issued prospectuses of next year's work. These contracts are to be advertised during the months of December, January, February, March, and April of 1920. It is thought by this early annouucement of the construction program that contractors will be given full opportunity to look over the roads, locate sources of materials, investigate terminals, etc. They will then be in a position to assemble plant and materials on the work, make financial and preliminary arrangements in advance of actual operations, and make it more nearly possible to complete a majority of the contracts during one working season.

Several highway departments, to help the material situation, have also carried on extensive material surveys and propaganda campaigns for the establishment of small local material plants, as well as securing available local supplies for contractors with crushing equipment.

Pennsylvania, as noted previously, has empowered her highway commissioner to purchase and acquire lands containing stone suitable for highway purposes; to purchase machinery and equipment to operate such quarries; and to use such stone for their own highways; besides power to sell, furnish, and supply stone to contractors engaged in building or maintaining roads under the department's jurisdiction. To increase the available supply of stone the States in this district have revised their specifications on stone used in concrete. The ranges now are from five-eighths inch to 2¾ inches. This will increase the amount available by 20 per cent.

If possible, material estimates should be allowed. To arrange for early and regular deliveries of materials in advance of actual operations is a considerable financial burden to a contractor, unless material estimates are allowed. Delaware's highway department, organized during the war of 1917, found it difficult to secure bids on her road work. With the announcement that substantial materials estimates would be allowed, her entire program was put under construction. Materials estimates are still allowed and during the past season when shipments were "spotty" and irregular, enough materials were on hand to tide them over, causing no delay in the work. The result has been an increase in mileage, made possible by the allowance of these materials estimates.

Contractors can assist by perfecting adequate organizations and employing labor-saving machines to replace some of their labor. Investigation and adoption in every practical instance should be encouraged, and orders placed early enough to insure their delivery for the present working season.

FACTORS IN THE SITUATION.

Producers of materials have organized an association and are making preparations to keep their plants in repair in order to keep up production. Cars will be loaded to their maximum capacity and traced to their destination. Their prompt unloading will be asked for.

But it is obvious that the controlling factor is transportation. To cooperate, the railroads must place in service all existing equipment, and keep it repaired to the fullest extent. If possible, new equipment should be purchased. Plants should be rated in accordance with their capacity and the distribution of cars made on such a basis without discrimination.

It is impossible to predict just what portion of this huge road building program will be built next year and what will be the course of prices. There is just enough uncertainty in labor and transportation, available material supplies, impending railroad strikes, and freight rate increases to make conditions seem actually worse for road building next year than they were this year. Perhaps the plan for efficient cooperation as outlined may be a remedy, but, as long as these disturbances continue, in face of the heavy demands for materials, there will be an underproduction rather than an overproduction. Due to this fact the general consensus of opinion is that prices will be no lower but rather higher during the coming year.

As to the expected exodus of labor to Europe, the United States Immigration Bureau reports that this is about normal. It is also reported that there will be a return influx of labor during the winter and early spring. This will have a tendency to stabilize labor conditions, and prevent any further increase of wages for common labor during the coming year.

But this is not going to deter or discourage the efforts to complete the program outlined. Since the war the public in this district has sensed seriously the commercial value of improved highways, and has generously backed up the program financially. In spite of the various and intricate difficulties, every effort and means will be exerted by the State highway departments to see it through.

Highway Situation in Central Western States.

F. R. White, Chief Engineer, Iowa State Highway Commission.

THIS summary of the highway situation covers nine States: North Dakota, South Dakota, Nebraska, Kansas, Missouri, Minnesota, Wisconsin, Illinois, and Iowa. The results of the survey have been grouped as nearly as possible under the six headings outlined by the chairman of the program committee, as follows:

APPROXIMATE CONSTRUCTION IN 1919.

Mileage of work contracted or placed under construction: During the past year, the several States of this group placed under contract approximately 7,400 miles of road. On nearly 75 per cent of this mileage, or approximately 5,000 miles, the improvement proposed consisted of constructing the roads to finished grades and providing the necessary drainage, but did not contemplate paving or other form of surfacing. On approximately 1,400 miles the improvement consisted of graveling or other similar form of surfacing. On the remaining portion, or about 1,000 miles, the improvement contemplated the paving of the roads. Illinois leads the list in mileage of pavement placed under contract, with approximately 575 miles. Wisconsin is second. In some of the States very little paving was contracted for.

Approximate cost: The approximate total cost of the work contracted or placed under construction was $48,000,000.

Work completed: In none of the States was the program of construction outlined for this year completed. The amount of work completed ranges from 20 to 85 per cent of the work contracted or placed under construction, the average being about 53 per cent. It will thus be seen that the Central Western States will carry over into 1920 a considerable amount of uncompleted work. This uncompleted work added to the program outlined for the year 1920 will make the accomplishment of the program for that year all the more difficult.

PRICES AND SUPPLIES OF LABOR AND MATERIALS, 1919.

Labor: One State, North Dakota, reports the supply of labor in 1919 better than in 1918. The prices, however, were 60 to 100 per cent higher than in 1918. One other State, Illinois, reports that labor was fairly plentiful, but very independent and, therefore, inefficient and not dependable. All the other States report a scarcity of labor during at least a portion of the year. In some States this scarcity was very pronounced. The prices of common labor varied from 35 to 60 cents an hour. The prices of teams varied from 60 cents to $1 per hour. As illustrating some of the difficulties with which the contractors have had to contend, one of the States reports that labor increased from 40 cents at the beginning of the season to 52 cents at the end of the season, while teams increased from 80 cents at the beginning of the season to $1 at the end, an increase of 25 to 30 per cent in labor and team costs.

Materials: Apparently in the majority of the States a sufficient supply of materials has been available. The main difficulty has been to get the materials transported from the point of production to the construction operations. In a number of the States there was a rise in the price of materials toward the close of the season, due no doubt to the poor transportation facilities which tended to restrict the available supply.

NEW OR PROPOSED STATE LEGISLATION.

North Dakota: A special session of the legislature is now in session. A bill has been introduced to amend the constitution so that the State may issue $50,000,000 in bonds for road purposes.

South Dakota: It is expected that new legislation will be enacted, making it easier to authorize hard surfacing road projects.

Nebraska: A new law which takes effect January 1, 1920, creates a State highway system of 4,500 miles and an automobile license fund of $2,500,000 for maintenance.

Kansas: A number of minor changes were made in the road laws to permit a better operation thereof. Also more stringent regulations were provided for the elimination of railroad crossings. The most important piece of legislation was the submission to a vote of the people of a constitutional amendment for State aid in the construction of highways.

Missouri: A law was passed at the last session of the legislature, giving more authority to the State highway department in the making of surveys and the preparation of plans for road construction.

Minnesota: New legislation proposed consists of an amendment to the constitution, providing for the construction of a trunk line system of highways of approximately 7,000 miles.

Wisconsin: State laws were amended so that the cost of surveys and right of way on Federal-aid projects can be charged to the project, thus very materially relieving the State highway department's administration fund. A new law was passed providing that advertising signs along the highways shall be removed.

Illinois: A new law was passed limiting the maximum axle loads permitted on any motor-propelled vehicles, to 8 tons. This law also places motor trucks and similar vehicles in a separate classification as regards license fees, the character of tires, etc. A law went into effect July 1, requiring that all highway bridges built in the State and costing over $200, shall be subject to the approval of the county engineer, who is a deputy of the State highway department. Another law provides that all bridges built in the State must conform to the structural requirements of the State highway department.

Iowa: A new law was passed creating a primary road system of approximately 6,000 miles, providing for the construction and maintenance of such system, creating an annual fund therefor, and providing for the issuance of bonds in anticipation of such fund. The motor-vehicle law was revised and the registration fees increased, so that it is anticipated that this law will produce approximately $8,000,000 annually, which fund will be used in connection with Federal aid in the improvement of the primary road system.

It will be noted from this brief summary of legislation that the trend is very strongly toward an enlargement of the program of highway construction, making provision for the better types of roads, providing for funds therefor, and placing more power in the hands of the State highway departments. The tendency also in this section is very strongly toward placing the major costs of a trunk line highway system on the motor vehicle rather than on real property.

One bit of legislation to which I would call special attention is that reported by Wisconsin with reference to the removing of signs along the highways. Personally, I do not see the necessity of permitting our highways to be lined with every kind of advertising sign as is now the case in most States. These signs, in addition to their generally unsightly appearance, often render the highway dangerous by cutting off the view at sharp turns. I hope to see the day when such signs will have entirely disappeared from our public highways.

BOND ISSUES PASSED AND PENDING.

Approximately $462,000,000 in bond issues have been passed or are now proposed, as follows:

Bond issues passed: Approximately $138,000,000 worth of bonds have been authorized. Principal of these is the $60,000,000 bond issue authorized by the State of Illinois, none of which has yet been expended. The next largest bond issue authorized is in the State of Iowa, where 13 counties have voted $18,500,000 in bonds.

Bond issues proposed: Approximately $300,000,000 in bond issues are proposed. Principal among the State bond issues proposed is the $75,000,000 bond issue proposed in the State of Minnesota. Wisconsin stands first in the amount of county bond issues proposed, these proposals running between $50,000,000 and $60,000,000.

Considering the vast amount of bonds passed, and the still greater amount proposed, it is apparent that the difficulty of the State highway departments of the Central Western States has shifted from one of finances to one of construction. It appears safe to say that no State highway department will be able, within the next two or three years, to spend the funds that are now actually available, or that it seems very probable will be made available in the near future.

PROPOSED CONSTRUCTION IN 1920.

It is rather early in the season for the State highway depar ments to give a definite statement of the mileage of each type of road proposed to be constructed during the coming year. Also from the way prices have been rising, it is difficult to give an estimate with any degree of accuracy as to what the cost of the work will be. Reports indicate that approximately 9,500 miles are included in the programs of the several States included in this group. Probably 60 to 75 per cent of this mileage will be improved by grading and draining only. The probable cost of this work will be about $102,000,000. These figures include only the primary, State, or trunk line highway programs. They do not include the construction or maintenance work which must be done by the various counties and townships. From experience in the State of Iowa as to the volume of expenditures by the counties and townships, it seems safe to say that at least another $100,000,000 will be spent on county and township work.

LABOR AND MATERIALS IN 1920.

It is anticipated that prices during 1920 will be at least as high, and possibly 10 to 20 per cent in excess of those prevailing in 1919. It is anticipated that the supply of labor will be about the same as in 1919. In some places there will be a shortage of labor, while in other places there will be a reasonably plentiful supply of labor, but it is expected to be independent and inefficient. The question of materials depends largely upon the railroad situation. It is believed that if assurance could be had that railroad facilities can be provided, additional capital would be interested and the supply of materials would be assured. With the present very great uncertainty with reference to rail transportation, it can not be expected that there will be a very great extension in the production of materials or in the capital invested therein. In order to avoid the very acute shortage of rail transportation facilities, many of the States are using every effort to produce materials locally.

The Motor Vehicle's Share in Highway Construction and Maintenance Cost.

S. E. Bradt, Superintendent of Highways of Illinois.

THE question propounded in the topic assigned to me is one calling for the judgment of each individual; and his answer will be governed to a certain extent by conditions existing in his own State; therefore, what I shall say may not exactly apply to all States, but will serve, nevertheless, as a basis for discussion.

The underlying principles of taxation are that taxes shall be levied, as far as possible in proportion to the benefits received, upon those who have the money with which to pay, and in a manner that will meet the approval of those who are to pay. The extent to which these principles are embodied in any plan of taxation, will be the measure of the equity and the success of the plan.

WHO BENEFIT FROM GOOD ROADS.

We naturally come back to the oft discussed question as to who receives the benefits from road improvement. That there is a general public benefit to our entire citizenship, applying equally to those who do not use the roads as well as to those who do, is beyond question. We are well aware of the fact that cheaper distribution provided by good roads will mean cheaper farm products for all the people, that more readily accessible schools and churches and places of amusement will bring about a general betterment of society, that the free movement of fresh foods to the centers of population will bring better health to the communities, that better roads bring better farm conditions and more intelligent farming, which will mean increased production.

In addition to these general, indirect benefits, there are direct and pecuniary benefits accruing to the users of the road. These, as you well know, arise from a saving of time to the car owner, a saving in wear of tires, a saving in repairs and in gasoline consumption, as well as in added life of the car itself.

What these direct benefits to each car owner will average annually is a question over which there may be considerable difference of opinion. I think I am safe in saying, however, that there are very few people who will not place these benefits greatly in excess of the license fees charged at the present time by any of the States. So long as these fees do not exceed these direct benefits the tax is just and the motorist is not being harmed.

S. E. BRADT

The motor license fees in Illinois averaged approximately $5 per car in 1917. In 1918 the fees were increased to an average of about $7 per car, and in 1919 the fees will average $10 per car. This fee will produce about $5,000,000 in 1920, which has already been appropriated as follows: For maintenance, $200,000, and the remainder to be expended on Federal aid roads in connection with Federal money. This, however, is not all that is provided for road work in Illinois. During the same period there will be raised by general taxation through county and township levies about $15,000,000, or three times the amount received from motor license fees. In other words, the motorist, because of the direct benefits he receives, will be called upon to pay $5,000,000 because of these direct benefits. I do not believe this represents the correct ratio between the direct and indirect benefits of road improvement, and am of the opinion that there is considerable room for further increase in motor fees before we reach the right proportion. The above increases, however, serve to show the evolution in legislation and the change in public sentiment toward levying a larger tax on the motor vehicle.

CAR OWNERS WILLINGLY PAY TAX.

Let us come back to the two practical factors in the problem of taxation mentioned above, namely, getting the money from the people who have it and getting it with their consent. The motorist not only has the small amount of money with which to pay his annual motor license fee, but is willing, even anxious, to approve any reasonable license fee that will bring about highway improvement. More than this, he is willing to pledge the payment of these fees over a long period of years as a basis for the payment of bond issues to be used for highway improvement. As evidence of this I would call attention to the fact that in Illinois the voters approved a $60,000,000 bond issue for highway improvement by a vote of 661,815 to 154,396, with the provision that the bonds and interest would be paid entirely from the motor license fees, which required a 100 per cent increase in those fees. Approximately one-third of the voters were motorists, and the most enthusiastic supporters of the proposition throughout the State were these motorists. I do not think that the people of Illinois differ very materially from the people of other States in their attitude toward questions of this kind. Therefore, what can be done in Illinois can be done anywhere.

For this reason I do not hesitate to say that if motorists can be assured that the money is to be properly expended they stand ready to give their approval to any reasonable, direct tax on motor vehicles for highway improvement.

PROPER USE OF MOTOR FEES.

There has been much discussion over the question "whether motor license fees should be used for construction," some people holding to the view that they should be used for maintenance only. In Illinois, we believe that the use of the funds, after they are raised, whether it be for one purpose or the other, or both, is a matter to be determined by local conditions. Maintenance is absolutely essential, and if a State requires for maintenance of its roads the entire amount derived from motor license fees, it is perfectly proper to devote it entirely to that end. If it requires only a part of the fees for maintenance then why not devote the remainder to construction? Our policy should be to charge reasonable fees somewhat in proportion to the direct benefit received and then use the money to the best advantage and where it will do the most good.

Ultimately the tax on motor vehicles reaches a very large percentage of the tax-paying population. Several of the States at the present time have an average of one vehicle to every 6 or 8 of the population. Illinois at the present time has one car to about every 12 people; but the present increase indicates that by 1923 we shall have one car to every 8 people. This means an average of nearly one car to a family. Therefore, while the motor license fee taxation will not be uniform as to the valuation of property, it will be fairly equivalent to a general taxation on the basis of the population.

PRESENT FEE BASIS NOT EQUITABLE.

Before closing I wish to say that it is generally recognized that horsepower rating as a basis for motor license fees is not equitable. The man who drives his Ford car 1,000 miles in a year pays the same fee as the man who drives the same car 20,000 miles in the same length of time. The man driving the thousand miles should undoubtedly pay more per mile than the man driving the 20,000 miles, but his total annual tax should not be the same.

We are all waiting for some ingenious individual to work out a more equitable plan, such as a graduated gasoline tax, whereby each vehicle owner would pay a fee in proportion to the weight of his car and the distance he drives it; that is, in proportion to his actual use of the road.

In conclusion, the demand which we are now facing for highway improvement, calling for a volume of money never before dreamed of in any scheme of internal improvement, places us in a position where we shall be obliged not only to use the old established methods of raising money, but to resort to any other equitable plan which may be devised. The raising of funds for this work by a license fee, to be paid by the individual who uses these highways and receives a large direct benefit from this improvement, is surely an equitable and proper source of revenue, and the benefit is so pronounced that the motorist stands ready to offer this assistance.

As has been indicated, the proportion which the motorist should pay toward highway improvement and maintenance will differ in almost every instance because of varying conditions. If fees are based on benefits to the motorist, it is apparent that the greater the mileage improved or maintained the greater the benefits; that is, the broader the scale of your plans the larger should be your license fees. These matters are for local determination in accordance with local conditions and local public sentiment.

DISCUSSION OF MR. BRADT'S PAPER.

R. E. Nornell, highway commissioner of Colorado: We, of Colorado, have a law, which was passed in the last legislature, which allows a tax of 1 cent a gallon on gasoline sold—a very appreciable amount each month. I think it is a very equitable tax, especially in Colorado or any western State, because we have so many foreign cars that come in and pay no tax whatever. In the collection of this tax I think we have received from $30,000 to $40,000 a month. A very large proportion of that comes from the foreign cars, as we term them. Our tax on foreign cars is a minimum amount, something like 25 cents for registration, and by the collection of the gasoline tax we get an appreciable amount for every vehicle that motors over our roads.

L. A. Gillett, State highway engineer, New Mexico: We have a law passed in the last legislature assessing gasoline 2 cents a gallon. We have received no money under this, for the simple reason that it is now before the Supreme Court of the United States on the question of constitutionality. That may happen in Colorado.

Herbert Nunn, State highway engineer, Oregon: It is pretty well conceded, I think, through all the States, that a fixed tax on any type of motor vehicle is unjust. It should be based on the consumption of gasoline, I think, and for that reason Oregon has been working on a proposition for the last 4 years, and succeeded last year in getting 1 cent a gallon tax. At this time we are clearing $300,000 or $400,000 a year, but the four oil companies are paying without question. We think it is an equitable way of taxing vehicles as each one pays according to weight and speed and the numbers of miles run. It is quite likely that in the next legislature an attempt will be made in Oregon to place another tax on the gasoline. The automobile in Oregon is exempted from direct taxation.

THE PLAN ADOPTED IN IOWA.

Senator N. Balkema of Iowa: In listening to this road discussion and to the taxation discussion, and the question of raising funds for road-building purposes, it seems to me that the legislature of Iowa at its last session struck the happy medium in placing a part of the burden upon the motor vehicle which it already had placed upon the driver or owner of the automobile.

I will speak of what we call the primary road system upon which we are placing the Federal aid, which comprises about 6 per cent of the road mileage of our State. The legislature, particularly the committee which had to do with the drafting of the bills that provided for this fund, believed in the theory that the road user should also pay the expenses of the road building, and upon that theory we proceeded. We found that about 85 per cent of the users of the road were motorists. This was determined through statistics of road users compiled by the commission, and by that it was determined that about 85 per cent of the vehicles used upon the road were automobiles.

Our automobiles are not taxed for general purposes. They are taxed only for road purposes and a license fee is placed upon them, based upon the weight of the car and upon the factory cost. I mean by factory cost the retail cost that the factory places upon its cars. This runs for a period of 5 years until it is diminished as the car reduces its usefulness upon the highways.

In addition to this, we feel also that the property owner along the highway has an interest in this matter of the road, and in the building of the road, and we have established a graduated scale, starting with the property that is located upon the highway itself, and running down to the property a mile and a half distant on either side of the road.

This explains our method of raising the automobile vehicle tax that goes toward the building of the primary roads. We have established upon motor trucks a similar provision. Our motor trucks are taxed in accordance with the weight of load they are supposed to carry, and in addition to that the weight of the motor vehicle itself.

We have other roads besides the primary roads, and the revenue for the building of these roads is raised by direct taxation upon all properties in the State.

THE GEORGIA LAW.

W. R. Neel, State highway engineer, of Georgia: The property of the man who owns a farm is benefited through increased valuation of the property. Now, if the farm land is increased in value, the taxes are certainly increased. And, thinking over the fairness of this question and in arguing it, I have been unable to find in our State anyone who has not benefited by the construction of these roads, and I have been unable to find any automobile owner who is taxed unjustly. We have a tax there of 60 cents per horsepower on all cars. That gives about $13.75, I think, for a Ford, and on up for the heavier cars.

I agree that the flat rate for the horsepower is unjust, because some cars use the road less than others, but that is the tax for the construction of the road. In addition to that there should be a tax on gasoline for a maintenance fund. I think that will be the next question that will come up in the State of Georgia.

In asking for the passage of this bill we appealed to the automobile owners. Committees from every county in the State appeared before the legislature and requested the passage of that bill, committees from owners of automobiles. They were the owners who were demanding this tax. I think if anyone should complain of the injustice of the tax it should be the owner. I know in one trip I spent $40 or $50 in repairing the tires and wheels because of the bad roads.

Problems of Administration--Proper Cooperation Between Adjoining States.

Arthur H. Blanchard, Professor of Highway Engineering, University of Michigan.

THE discussion of this subject should be handled without kid gloves. In any remarks which I may make there will be no intention of discussing technical features, of specification, of materials, or methods of construction. In order, however, to handle the subject intelligently it will be necessary to point out differences which actually exist.

The reasons for the many differences which exist in specifications for materials and methods of construction in a given geographical section may be legitimate. Such differences may be based upon the differences in the character of materials available and other local conditions. But many of the differences I believe have grown up, like Topsy. It therefore is of the utmost importance that we should not camouflage differences which exist by using that very favored expression of highway officials, that the difference is due purely to local conditions.

In consideration of the cost of materials and methods of construction there is a certain economic fundamental principle: Standardization of materials, methods of construction and machinery, clear and definite specifications, a maximum equitable competition among producers and contractors will reduce the cost of materials and the cost of highway improvements. Upon that basic principle will be based the remarks which will follow.

This subject may be considered under various heads. Naturally, the first head deals with the necessity for considering cooperation among the States in a definite geographical section. It should be realized that the time is approaching when the spotlight of public opinion will be brought to bear upon the work of every highway department, and the responsibility of the men in this audience should be fully realized, for the billion of dollars to be expended next year on highway improvements will depend in a great part upon the work of the men represented here. It therefore is of the utmost importance that everything be done which will reduce the cost, at the same time maintaining the efficiency of the highway work.

We do not need to take much time in considering the conditions which will exist if we can not have cooperation. All of us know, for example, that a group of brick companies are able to produce one size of brick at a much lower cost than those companies could produce any one brick if they were required to manufacture 10 sizes. This point was well appreciated in France back in 1910 when it was found that the 57 proverbial varieties of stone block were being employed in the various municipalities of France, and after they got to work on that problem, following a second International Road Congress in 1910 at Brussels, the sizes were practically reduced to 5, with resultant saving. The reduction of cost of production is well illustrated by the thousands of articles of merchandise sold for 5 and 10 cents in the Woolworth chain of stores. The principle there involved need not be expanded. The necessity is self-evident.

What should we endeavor to accomplish? Before considering that phase it will be advisable to look into the situation which exists; and, of course, to take the whole United States it would be impracticable to cover the problem in the brief period assigned to me. I have therefore selected a given geographical section, including Wisconsin, Michigan, Illinois, Indiana, Ohio, western New York, western Pennsylvania, and Kentucky.

SOME EXISTING DIFFERENCES.

Some of the differences found in the specifications of those States will be brought to your attention. Please bear in mind that these points are brought to your attention not in the spirit of criticism but to show you that in a great many instances it will be practicable, through a cooperative effort, materially to reduce differences which now exist in specifications for materials and methods of construction. Take, for example, as the first illustration, the water-bound gravel road. In this connection, a great many plants of considerable size are supplying gravel. It is self-evident that in the case of gravel and broken stone the greater reduction we can make in the number of sizes required the lower will be the cost of production. And in this connection it is a basic principle that whenever specifications require special sizes, or special machinery, or complex methods the public pays the cost.

In the case of gravel for the top course of the water-bound gravel road we find, running through these various States enumerated, sizes ranging anywhere from a maximum of 3 inches down to a minimum of gravel passing a 1-inch screen.

In the case of broken stone for the water-bound broken-stone roads we find as many differences, running from a maximum (and this is for the same kind of rock as far as the specifications are concerned) of 3½ down to 1½ inches.

Of the seven States having specifications for water-bound broken-stone roads no two call for the same product. And yet it is well known that the same commercial plant is required to supply broken stone for many of the States in that group.

THESE SPECIFICATIONS ARE OUTLAWED.

In connection with specifications for broken stone, it should be borne in mind that the time is past when we can call for sizes by the old worn-out nomenclature of "nut" or "egg" or size "1½" or "2½," etc.; that the time is past when we can follow the practice (which was an improvement on the old practice, I will admit) of calling for the size of broken stone by the usual specification that it shall pass over a screen having a certain size hole and through a screen of the next size hole. That method of specifying broken stone may work out satisfactorily in the matter of water-bound broken-stone roads, but when we come to dealing with the higher forms of pavements in which broken stone is used it doesn't prove satisfactory. If I could read to you a number of analyses of products complying with a given specification I think some of you would be astounded at the difference which exists.

Now, in the specifications which I have before me (and they are scientific specifications) there has been included for the sizes of screen the following: Passing a 3¼-inch not less than 95 per cent; passing a $\frac{1}{100}$-inch not more than 15 per cent; passing a $\frac{1}{10}$-inch, 30 per cent to 70 per cent. Those limits are based on the experience of the engineers in that particular State who desire to have a certain product furnished them for use.

In that same specification there is found for the base course that the size of stone shall be: Passing a 3-inch screen not less than 95 per cent (that is definite, of course); passing a 1½-inch screen not over 10 per cent. That last specification, gentlemen, I do not consider a definite specification, and I want to say now that you can bank on it (and this is based upon experience as a consulting engineer to many contractors during the last eight years) that if your specifications are not definite the contractors are going to put a figure on their bids that will cover any questions of which they are not sure.

The point is, in regard to this specification for broken stone, which I find is being used in a great many States, that the clause, "passing a 1½-inch screen not over 10 per cent," in my opinion will not hold in any litigation as meaning that there must be present some stone which will pass a 1½-inch screen. I am not sure exactly what some engineers mean by it. There is no definite requirement there. It simply says "not over 10 per cent." You will find that characteristic of a great many specifications where it is of the utmost importance that a certain per cent should pass through the 1½-inch screen. It is simple, of course, to remedy a specification of that kind and make it definite, so the contractor or producer will know exactly what is required, by simply inserting "not more than a certain per cent and not less than a certain per cent."

Another example: In the specifications covering one kind of bituminous concrete pavement, where it is of the utmost importance that a desired size should be obtained, the specification reads like this: "All of the broken stone shall pass a 1¼-inch screen." That absolutely settles the maximum size. "Not more than 10 per cent nor less than 1 per cent shall be retained on a 1-inch screen." That fixes the amount of the maximum particles in that product.

This is for one product of a crushing plant: "Not more than 10 per cent nor less than 3 per cent shall pass a 1¼-inch screen." That fixes absolutely the minimum size in that product and the producer and contractor know exactly what is expected of them.

In the case of cement concrete pavements we reach a type in connection with which there is a material used which stands by itself, namely, cement. We have there the uniformity which is desired on the basis of having all the specifications simply refer to the standard requirements of the American Society for Testing Materials.

When we come to the coarse aggregates, however, we have all sorts of combinations, and it must be remembered that the broken stone and gravel employed for these coarse aggregates in many cases serve a given area which laps over various States. For instance, the Chicago commercial plants serve in some cases parts of Wisconsin, Illinois, Indiana, and Michigan. Whether they get down into Ohio or not I do not know. But in the case of those four States the specifications are entirely different.

INDEFINITENESS IN SPECIFICATIONS.

Branching off from materials for a moment and coming to the matter of the distributor used in the production of bituminous macadam pavements, for the distribution of bituminous materials, here we run into that extermely indefinite clause so often found in specifications: "A type will be satisfactory which is approved by the engineer."

The time has arrived when such clauses should be eliminated from specifications. If a man knows enough to go to a distributor or a roller or mixing machine and pass on it after the contract is awarded, he should know enough to be able to put into the specifications an intelligent description covering the points which he considers essential.

Now for the definite illustration to which I referred a few moments ago. In 1914 that specification occurred in the specifications of New York State. Mr. Hubbard and myself were investigating conditions in that State for one of the State departments. At that time there were 9 divisions. The highway commissioner, when this matter was discussed with him, said that the approval was up to the division engineer. In investigating the work of the 9 divisions we made a point to take up with the division engineer his ideas in regard to what an approved distributor should be. We found that in the State of New York there were 9 distinct ideas in regard to an approved distributor.

Now, a contractor was in this position: That he must, through some means (underground or otherwise) find what were the ideas held by that division engineer before he could intelligently bid on a job. I have in mind two contractors whom I have served, both of whom added to their contract price for bituminous macadam pavement $2,000. Furthermore, they got the jobs. That $2,000 was put on because they were going into a State where they had not before worked, and they were not familiar with the ideas of the engineers in that particular State in regard to what an approved distributor was, and they were not going to take any chances. They intended to have an item in their bids covering the overhead for the purchase of a new distributor. And that thing crops up time and time again wherever this clause of "approved type" of machine or method is included.

In connection with bituminous macadam pavements we furthermore find quite remarkable differences in the specifications for the bituminous cements to be employed. It is perfectly true that, depending upon the geographical location of the work, a difference in penetration is necessary. In this particular case, however, it is not sufficient to account for the wide difference in penetration of the asphaltic cements which exist except in the case of (let us say) Kentucky on the one hand and northern Michigan on the other, or northern New York, or Wisconsin.

If a bituminous material company has to manufacture a great many concretes, and keep all of those concretes in stock, you are paying for it. Don't forget that. That must be a fundamental consideration. The same thing exists in regard to the other properties, physical and chemical, of the bituminous cements employed.

AS TO ROLLER REQUIRED.

I have alluded to materials heretofore. I will not allude specifically to the differences which exist, but I do want to refer to the matter of rollers required. The rollers vary anywhere from 5 tons to 10 tons. I don't say that the engineers of this State are not entirely justified, because I am not taking up the technical features to any extent. But let me read you this: "The initial compression shall be effected with a tandem power roller, weighing approximately 8 tons, having a roll of such width as to give a compression of approximately 250 pounds per inch width of spread."

As far as it goes, that is excellent—a very admirable specification. But here is the point: "Final compression shall be effected with a power roller weighing not less than 10 tons." In other words, two rollers are going to be required on that job, specifically requiring an 8 ton and a 10 ton.

A contracting company which makes a practice of constructing sheet asphalt and Topeka bituminous concrete in all probability will not have a 10-ton roller. It means then that the results obtained must justify that added cost. It happens that that is the only State in this group that requires a 10-ton roller; therefore contractors who are used to the work in the other States, in providing their equipment before going into this State, must take care of that overhead of the 10-ton roller in making their bid.

A rather interesting technical detail is, that as far as the compression secured is concerned it does not make a bit of difference, because there is nothing specified here in regard to the weight per linear inch of tread for this 10-ton roller, and those who have made an examination of rollers know there are some 10-ton rollers that only have a 250-pound limit.

Furthermore, in this specification, for the binder course an 8-ton roller is allowed. The practice of using two rollers on a job is as old as the hills. It has been followed in New England for a great many years, but there is considerable difference in the weight of rollers used. If a 5-ton roller is used for the initial compression, then 8 or 10 tons may be used for final compression on certain classes of work. But such requirements as that should only be put in after it is determined that the results will warrant the additional cost of construction.

THE BITUMINOUS CEMENTS.

In the case of the bituminous cements employed for Topeka bituminous concrete we find as many differences as we do in the specifications for bituminous cements for bituminous macadam pavements. Let us take just one example. Take ductility. We find "less than 15 centimeters," "not less than 30," "not less than 60," "not less than 100." I believe you can get together on such requirements as that, because those differences mean that the asphaltic cements for those various States have to be manufactured some time before in a good many cases.

In regard to the size of brick the various States mentioned differ to quite an extent, so that if one company proposes to supply all of them it must manufacture several sizes.

There is one specification which appealed to me as being extremely definite. It reads: "The length shall be between 8 and 9 inches, variation $\frac{1}{2}$ inch; width, $3\frac{3}{8}$ to $3\frac{5}{8}$ inches, variation $\frac{1}{8}$ inch; depth, $3\frac{3}{4}$ to 4 inches, variation $\frac{1}{8}$ inch." That is a specification which gives a producer and contractor the exact idea of what is required.

THE SOLUTION OF THE PROBLEM.

In dealing with the matter of brick specifications my previous remarks were based upon the belief that it must be true that a great many engineers have more or less blindly followed the recommendations of certain associations of engineers. I think the time has come when every engineer must think for himself and adopt no method in connection with any type of pavement unless he is fully satisfied that that method contains inherent merit.

Now, the solution of this problem seems to me very simple, provided that those who hold the purse strings in our several States will realize the ultimate economic advantages resulting from uniformity in specifications of materials and methods of construction in adjoining States. It would seem simple that for a given geographical section a committee representing engineers from the several States could meet—meet often, and in some cases for long periods—and thresh out these differences and decide which differences are dependent upon local conditions, which differences are based upon legitimate differences of opinion among the engineers in regard to the proper materials and methods to employ, and which differences are of such a character that they may be eliminated.

DISCUSSION OF MR. BLANCHARD'S PAPER.

C. P. Fortney, chief engineer West Virginia State Road Commission. The question was handled by Prof. Blanchard, apparently, from the standpoint of specifications and standardization of material.

Our State is very peculiarly situated, especially in regard to costs. In the northern end, for instance—we have a panhandle extending into Pennsylvania between Pennsylvania and Ohio—we have one price up there. Then over in the eastern panhandle, which is affected by Virginia and Maryland, we have another set of costs. Down in the southern end, which is affected by Virginia and Kentucky, we find something still different. Then we have a county system. We have 55 counties, and the State road commission acts in a supervisory capacity, so in effect we have 55 free States.

But from the standpoint of specifications we have a State standard; so the question of difference in standards would not necessarily affect this difference in cost.

I notice that, to the north, where the road building is going on very intensively, the costs are higher. Over in the southern part, we are paying, say, $1.25 a yard for excavation; in the center of the State, where little construction work is going on, we are only paying about 56 cents. So something else comes in there.

It is the same way with material. Take the question of brick, for instance. We have the Mack block manufactured in the northern Panhandle, and we put that in our specifications. Transportation of material enters into the question here, and labor also. The question of transportation may modify or influence conditions somehow.

When we come to the standardization of the specifications West Virginia is somewhat of a small United States in itself.

Then we are confronted with getting contractors, and several other things, and we have these 55 counties bidding against one another. That runs the prices up. We try to eliminate that as much as we can. We have to pay twice as much in one section of the State as in another. That is due partly to the disposition of some of our neighbors. Frankly, I don't know what Col. Uhler is doing up in Pennsylvania except through what I learn from the bonding companies when we get bids. I know in a general way what Mr. Coleman is doing in Virginia; also what Kentucky is doing. But I do know that the people in Pennsylvania must want them as much as we do in West Virginia. That puts us bidding against one another.

I wonder sometimes if we are not forcing prices up ourselves. The contractors know we want the roads and just boost the prices, and it is a question of how badly we want them, how much we want to pay for them. They balance one against the other. I think I voice the sentiment of our commission when I say that if any of our bordering States want to cooperate with us we will tell them exactly what we wish to do, give them next year's program, say how much we are going to spend, and they can say what they are going to do. We may help one another that way.

The tendency is for prices to keep going up because we can not, as I said a moment ago, influence labor. As to the question of material, West Virginia is not troubled so much by that, for it is superabundant. There are only one or two countries where we are troubled with the question of transportation. The next thing that is going to concern us next year is whether we can not do a little bit more by getting away from labor and getting machinery instead.

DIFFICULTIES IN GEORGIA.

W. R. Neel, State Highway Engineer of Georgia: In thinking over this very important subject I am like Mr. Fortney, though I have not been able to arrive at a solution, I have found a great many of the difficulties. As I see it in my section of the country, the principal difficulty that has confronted me has been the short supply of road building materials, the limited number of contractors, and the inadequate service from the railroads.

In looking for a solution of these principal problems, I have thought of the advisability of the State's opening quarries, not to compete with the people who are already in that business but to encourage the contractor. Now, the contractor bids, and he admits he is taking a big gamble. And you all know that, under our present system of letting contracts, the contractor is a gambler, and right now the odds are pretty heavy against him. With the possibility and probability of railroad rates going up month by month, and the labor situation just about as bad as the railroad situation, and the short supply of materials, the contractor must bid a very high price. There is such a great amount of work that he does not have to bid low in order to get work; it is just a question, as I see it, of his conscience—and my experience in attending the lettings for the last 6 or 8 months has been that his conscience is growing less sensitive at each letting.

I am sure it is not from experience that the contractor has raised his prices steadily, because I have seen the same contractor bid from week to week and get 4 or 5 contracts, and none of the work which he had bid on had commenced, so it was not from experience that he found he had to bid higher. It was because he saw he could get the work at the higher price.

I think that maybe we can help solve the problem before having the committee (following out the suggestion of Prof. Blanchard) representing the different States as they would be affected in each group, meet and work out the standardization of specifications. I think that is a very important point. I admit it is a point I had not thought of. But that feature of the possibilities of reducing the cost of the work I think can be worked out very satisfactorily.

Then, if we could find means of specifying as nearly as possible local materials, we might not only find a solution of the transportation difficulties but also leave for our neighbor States the materials that they have available locally.

It might be that we would have to experiment some and use materials that are as yet of unknown value. But in order to advance science I think a certain amount of experimenting is necessary.

I do not believe we have yet arrived at the point when we can standardize all features of road construction. I do not think we have yet arrived at the point where we can standardize road-building equipment. I think, as Prof. Blanchard has suggested, that we can cover in our specifications certain essential features that we now retain, as necessary; but I think we should leave other features for future development, because I am satisfied that we all agree that we have not yet arrived at the ideal road. We must meet the changed conditions from day to day and we must allow people's ideas to be put into effect as much as possible. Of course where such ideas are radical those in authority should confine them to a limited expenditure. Working along these sane lines, we might get to a point where the benefit of cooperation would tell in the cost of our roads.

Another point that has occurred to me that might reduce the cost of roads would be careful study of our present system of letting contracts. I believe that the bidding of a fixed sum is all wrong. In Georgia we have such a small number of contractors to do this great amount of work that there is absolutely no competition, and I think if we were to work out a form of contract that would be more businesslike and in which there would be less of the gamble, we would get more business men, and the use of larger amounts of capital employed in the construction of our roads.

MIDDLE STATES UNITE ON SIZES.

W. G. Thompson, State highway engineer of New Jersey: I would like to inform the association of a movement started which is quite in line with Mr. Blanchard's suggestion. At the instance of Col. Uhler, of Pennsylvania, a meeting was called in Philadelphia, about three weeks ago, of the highway officials of the States of Pennsylvania, New York, New Jersey, Delaware, and Maryland, with the stone producers. Col. Uhler's idea was that in order to increase the output of the quarries, which in our locality is almost up to its limit now under the present system of working, some change should be made which will enable the quarries to increase it.

We discussed the proposition of agreeing on minimum and maximum sizes of stone to be used for concrete work, for example, and for such macadam pavements as may be built hereafter. It was found that the maximum and minimum sizes used or specified for use in each of the States was different for each State. We finally agreed upon sizes which will be used hereafter in these States (with slight exceptions possibly) which will increase the output of the quarries about 20 per cent in some cases.

In other words, by agreeing upon the maximum size (which I think was passing through a 2¾-inch sieve and retained upon a 2⅝) for concrete, we were able to get together with the producers. All agreed upon that and it will have a tendency to lower the price where a large output is used because heretofore the quarries have had to comply with different requirements for each community and that of course restricted the output, because of the many sizes required, and the many bins or storage houses required to take care of the surplus product. The movement, I think, will become more widespread. The same method may be applied to all of the products used in road construction.

UNIFORM SPECIFICATIONS BENEFIT.

Clifford Older, chief highway engineer of Illinois: About a year ago the engineers of the Northern Mississippi Valley States (11 in number) met in conference to determine this question as to the sizes for concrete road construction that would be adopted as uniform (if it were possible) for the 11 States.

We adopted such specifications and recently I made a visit to 16 gravel aggregate producing plants in northern Illinois to determine something about how this thing was working out. I found, to my great satisfaction, that in these 16 plants, which produce about 4,000,000 tons of coarse aggregate per year, that the answer to my question as to what was the demand for road construction aggregate was practically the same, and that was, that the demand was in accordance with the specifications adopted by this Mississippi Valley conference. There were very few exceptions and those came from small villages and cities where miscellaneous engineers handled the work. But for large city and State construction the same size of aggregate was in demand. The only difficulty outlined by these gravel producers was their trouble in handling the orders of cities where smaller aggregate is required for reinforced concrete building construction. However, they all agreed that the new schedule of aggregate for road construction purposes had simplified and lowered the cost of producing gravel.

I believe the same answer would have been given by the stone producers, although I have not yet been able to visit those plants. I am just giving this as an example of what has been done along this line.

A. R. Hirst, State highway engineer of Wisconsin: Apropos of this discussion and of the point made by Mr. Older, I wish to say that in these 11 western States we have an association of State highway officials devoted to specific problems of road affairs. I believe it is the oldest organization of the kind in America and the forerunner of this larger organization. As far as Wisconsin is concerned, and I believe the other States join us in this, we would not know how to do business without the association. We get together at least once a year and if we can not wind up the business at that time we establish a committee, such as this aggregate committee, and it is a fact, that in that group of 11 States we are practically uniform in our requirements and we are getting more so every year. I recommend to other States the formation of similar associations.

Is State Supervision of Construction and Maintenance of all Highways Desirable?

B. H. Piepmeier, Construction Engineer of Illinois Department of Public Works and Buildings.

BEFORE this question can be answered intelligently, it is necessary first to investigate the general location of the public highways, the purpose for which they were established, and the source from which the funds are received to pay for their construction and maintenance.

On account of the nature of our traffic on the public highways, all roads within the boundaries of a State do not serve their purpose in the same way. Some roads accommodate primarily local or community traffic, some intercommunity or county traffic, others intercounty or State traffic, and a few interstate or through traffic. In view of the varied purposes for which public highways are used it would not seem to be economical nor desirable for any one political unit to have complete control of their construction and maintenance.

In a few of our States and portions of other States the majority of the roads are located, primarily, to serve villages or community centers. Many of the villages are widely separated and frequently in different counties. Under these conditions it might be economical and desirable for the State as a unit to have complete control over the construction and maintenance of all roads.

In our agricultural States we have a much different condition. Here we have a very large mileage of roads in comparison to the population or area served. The difference between the two classes of States is illustrated by data published by the United States Bureau of Public Roads, which shows that Rhode Island has 250 people to every mile of public road, or 1¾ miles to every square mile of area, while in Iowa there are 21 people to every mile of road and about 2 miles to every square mile of territory. It is very evident that the road problem in these States is somewhat different and while State control over all construction and maintenance in some States might be desirable, it would not be in others.

In the agricultural States a very large mileage of the public highways is of value, principally, to local communities. Such highways are of interest, primarily, to the people who live within the immediate communities; hence, their construction and maintenance should naturally be under the control of local officials.

CONTROL OF STATE AND LOCAL ROADS.

Inasmuch as all road and bridge construction and maintenance involves engineering principles and skill which can be obtained only by experience, it is advisable to have all local road officials report and be responsible to a competent county commissioner or engineer who should in turn be responsible to and under the general supervision of the State department.

In every State there are a number of highways which should be termed strictly county roads, as a large percentage of the traffic upon them extends from one community to another. Their construction and maintenance might be logically come under the control of a county commissioner or engineer, thus making such roads serve as main feeders to a State system.

The residents of every State are increasing their fields of social and commercial activities annually until to-day it is apparent that no local or county unit should be required to bear the burden of the construction and maintenance of all of its roads. Practically every State in the Union has realized the economy which is inherent in State control over a number of its roads. The exact mileage of roads the State should control is perhaps a debatable question and will be as long as traffic conditions are changing yearly. It is evident that the thickly populated States should have more roads under their control than the sparsely settled States.

Experience has proved to practically all State road officials that partnership with political subdivisions of the State in the construction and maintenance of roads is very unsatisfactory. It seems desirable, therefore, that all roads within the boundaries of each State should be divided equitably between the individual communities, the county, and the State, and each unit have the direct responsibility of the construction and maintenance with such general engineering supervision from the State department as is necessary to control irregularities.

FEDERAL AID AND THE STATES.

During the past few years there has been considerable argument advanced favoring an independent Federal system of roads with the Federal Government controlling all construction and maintenance. There is no argument against an interstate system of improved highways, as traffic is demanding such a system and all road enthusiasts are looking forward to its realization. In my opinion the public is not demanding a Federal system of roads with complete Federal control, but it is demanding a connected system of improved trunk-line highways. Any method or plan, therefore, that will secure such a system, in the least possible time and in the most economical way, will meet with the unanimous approval of the public. There is no question but that the recent Federal-aid plan has met with approval and has induced many States to take up road construction that would not have done so without this aid. It is reasonable to believe, therefore, that under a Federal-aid law there will be a greater mileage of improved roads constructed and a trunk line or Federal system of roads secured in less time and in a more economical way than under any other plan.

Present conditions would indicate that it would be more desirable to all concerned if the respective States had complete control of all State and Federal highways with such general supervision from the Government on all Federal highways to insure that the roads in each State would connect at the State lines, and to see that the Federal money was actually spent on roads which are generally recognized as suitable for the traffic that might be expected. Where the State has a highway department and furnishes any portion of the money in a Federal road, its engineering department should be, and generally is, competent to supervise all construction and maintenance work within the boundaries of the State. In Illinois the present plan of Federal supervision has proved to be very desirable.

WHERE CONTROL SHOULD LIE.

When proper engineering supervision is supplied, it is generally more satisfactory for the political unit which is financing the work to control the construction and maintenance. It is apparent that the local unit as well as the county unit must depend upon direct taxes to finance its road improvement; hence, should control the work, providing that proper engineering supervision from the State department is assured.

On account of the large territory which is covered by the average motor vehicle, it seems equitable that all fees derived therefrom should be used exclusively by the State and on intercounty or State roads.

In conclusion, therefore, I would deem it desirable for all road construction and maintenance under existing conditions to be divided as follows:

All district or township road work to be under the direct supervision of local road officials.

All county roads to be under the direct supervision of the county officials, and all State and Federal road work under the direct supervision of the State. The Federal Government should have general engineering supervision over Federal-aid construction, the State general engineering supervision over all county and township or district road construction and maintenance.

Proper Inspection in Development of Material Supplies for Heavy Programs.

A. B. Fletcher, State Highway Engineer of California.

IT IS indeed a day of heavy highway programs; we talk as glibly of forty, sixty, or a hundred millions of State highway bonds as we did a few years ago of five or ten millions. We talk now of annual programs of highway construction of from ten to twenty-five millions without particular difficulty.

But talking about such programs is one thing and getting experienced engineers and assistants, finding enough contractors of sufficient ability and financial responsibility and securing the huge quantities of proper materials of construction promptly is quite another story.

Hardly any two States of the Union have the same problem to solve. In some of the States where State highway activities are of very recent date the troubles with respect to the supply of materials of construction must be acute and hardly any State has been accustomed heretofore to thinking of the supplies in terms of the enormous volumes we are now facing.

The public now in thinking of or speaking of a State highway has in mind an expensively paved road. In general it may be said that the days of gravel or waterbound macadam roads are no more. In most of the States the location of the principal supplies of gravel, sand, and broken stone is fairly well known, but for extensive paving operations these supplies must be increased greatly and new deposits located, if the highway work is to proceed with the dispatch desired by the public.

Often the engineer must decide whether he can or must use materials of somewhat inferior quality or whether materials of better quality can be shipped to the work by rail. These decisions often require nice judgment and no highway department can consider itself well organized without a geologist competent to assist the engineer in such matters, nor unless it have a well-equipped testing laboratory with trained assistants to operate it.

SUPPLY OF MATERIALS.

In many instances the material supply difficulty is not so much the lack of material as it is the failure of the railroads to ship it promptly and as ordered. In some States it is notorious that the railroads do not have enough suitable cars to give the needed service and this is true particularly at the crop-moving periods. Hardly anything will do more to disrupt a highway contract than the failure of the railroad to furnish the materials of construction as they are needed.

A. B. FLETCHER.

This failure of the railroads unless it can be corrected otherwise would, doubtless, in some States with heavy programs, justify the purchase of railroad cars by the State department for highway use.

If the railroad may be depended upon, the economical way of handling the materials, particularly such stuff as broken stone, sand, and gravel, is to unload from the cars and place the materials on the road where they are to be used without unnecessary rehandling, which is always a costly performance.

Failing prompt railroad service, and in these days we rarely expect regular deliveries, one remedy is to stock pile the materials at convenient points. Sometimes, but not often, it is possible to haul the materials and place them in small piles within the right-of-way, but more often they have to be placed in large piles near the railroad sidings.

The use of portable derricks or cranes with clamshell buckets to a large extent lessens the rehandling expense but whether machinery is used or not it seems obvious that the materials must be available when the contractor needs them.

Doubtless it will also be found that because of the extraordinary number of motor trucks supplied by the Government to the States at an almost negligible cost much material may be hauled in these trucks for long distances. The ton-mile cost of hauling in trucks which cost the States practically nothing is greatly reduced if the factor of original cost of the trucks does not have to appear in the figuring.

SUPPLY OF MATERIALS BY STATES.

Some of the States have adopted the practice of furnishing the materials of construction or most of them to the contractors. The writer does not know of any State which has gone so far as to own cement plants and rock quarries and to operate them, but that such a policy may have to be adopted by some States is by no means unthinkable. Indeed the statutes of some States provide for such a contingency. For such States as have become accustomed to supplying the contractor with construction materials it would be a simple extension of their operations.

There is little doubt that heavy road building programs will be in fashion for a long time to come, so that the plant construction cost may be distributed over a huge quantity of the product. If the cement companies are unreasonable in their prices, this policy would afford a means of curbing them. However the money involved in such undertakings would be in large figures and could be allotted only with difficulty in some cases. "We want the money spent on the roads" is still the slogan of many of the thoughtless voters of State highway bonds. It must be confessed, too, that under normal conditions no State-operated cement plant can hope to compete with a privately operated plant on the cost basis. There are many advantages and few objections to the State highway department furnishing materials to the contractor. A contractor with little capital is enabled to bid on work since he has little to finance outside of the labor and equipment items. The contractor has no incentive to skimp on quantity or quality of the materials. Indeed he must be watched to prevent him from wasting them. All disputes with the contractor as to the quality of the materials are eliminated.

Because of the larger volume of materials in which it deals, the State can usually secure lower prices per unit than can the individual contractor. The contractor will insist of course on prompt deliveries. He will be much more critical in this respect than if he were doing the purchasing himself, and he may claim for damages due to faulty deliveries, but the State should and can operate better than the contractor in this respect.

It costs something to handle the business end of course, for purchasing agents and clerical people to buy and route the materials and for this service the contractor, when he furnishes his own materials, charges from 5 to 10 per cent of the value of the materials. This cost is reflected, necessarily, in the administrative costs of the State highway department and there is much bother connected with the supply of materials to the contractor. The advantages, however, seem to outweigh the disadvantages.

STATE TESTING LABORATORY NEEDED.

So much costly paving is involved in modern State highway construction that the testing of the materials used becomes an important division of the work. The geological work and the testing may be combined in one department without difficulty and a highly trained geologist may be placed in charge of both branches of the work.

It is hardly possible to make up cost estimates until the sources of the materials are known and the geologist and the testing engineer often settle the matter for the engineer. After construction work begins, it is necessary from time to time to test concrete mixtures, both asphaltic and Portland cement in order to get the best results, since although the ingredients have all passed the specification satisfactorily, the limitations of the specifications for the combinations nearly always permit some latitude. It is also interesting to know, for instance, the compressive strength of the concrete in the pavement slab after the road is completed.

A testing laboratory can be set up at no great cost, probably in no case exceeding $10,000, which will do all the testing required in the general line of work. The United States Bureau of Public Roads requires the tests to be made and it seems to be advantageous to have the work done by the State highway department rather than to rely on private firms of testing engineers.

DISCUSSION OF MR. FLETCHER'S PAPER.

By F. E. Everett, State Highway Commissioner of New Hampshire: During the last three years highway engineers throughout the country have had forced upon them the realization that in order to carry out a program of construction or maintenance, some means must be devised to insure the delivery of material.

To arrive at the solution of the problem, it is necessary, of course, first to consider the cause. We are told by every material concern that there is a car shortage, that the railroads do not furnish them enough cars to take care of their output. Investigation of a few commercial plants in New Hampshire has shown this to be a fact. Road builders everywhere have been busy for the last two years attempting to impress upon the proper authorities the necessities of alleviating this evil. Some results have been accomplished, but not enough. Neither have we any assurances that this improvement will continue. If we are unable to get relief from the railroads, it is evident that we must devise some scheme that will entail the minimum use of railroads. By doing this, we will help not only ourselves, but also the railroads, which we are told are badly congested.

The development of local natural resources, if they are of value, will answer this problem. With this end in view the New Hampshire Highway Department during the seasons of 1917 and 1919 conducted a rather extensive geological survey of the State. The results obtained have greatly exceeded expectations. Trap-rock dikes have been located in nearly every section of the State. Native granites have been located and classified as to resistance to wear. Gravel deposits have been tested and classified as to their availability and quality, and the limits of the bedrock strata have been located and a study made of the effect of the bed of rock on gravel deposits.

Laboratory tests of the trap rock which have been located show it, in every instance, to be of better quality than that which we have been importing. Several trap dikes are located within easy truck-hauling distances of proposed heavy construction. Practically all of them could be used to take care of some work within reasonable hauling distance. Of course it is necessary in order to accomplish our purpose to expend a large amount of money in plant equipment. Taking into account the large amounts which have been thrown away waiting for material to be delivered by rail, is not this expenditure for plant equipment warranted?

Gravel roads constitute approximately 75 per cent of New Hampshire's total State road mileage. It is therefore evident that we are dependent in a large degree on our gravel deposits. This being the case it is imperative that we know exactly how we are situated regarding this valuable material. Our geological survey had given us this information in detail.

SURVEYS LOCATE VALUABLE MATERIAL.

By means of the survey deposits of inestimable value have been uncovered and good gravel has been located in sections where before it was not supposed to exist. This has, therefore, helped, in large measure, to solve the transportation problem, as it was necessary to import material into these sections before. Where a particularly good bank has beeen located, the State has taken steps to purchase, thereby insuring the use of the material without hindrance and also its conservation for road purposes. With this information at hand it seems that the material used in construction can be placed on the work at the time planned. Also it is likely that our estimates conform more closely to the actual cost.

The development of material supplies is not the only result realized from the geological survey. The testing of material to be used in road construction has been greatly facilitated. Hundreds of samples from every section of the State have been tested, and the data obtained has made it possible for us to make up a map of the State showing the quantity and quality of all materials. Also a map has been plotted showing the location of the different bedrocks. It is surprising to note the uniformity of effect of the glacial action over the bedrock on the adjacent deposits. It is possible by an analysis of bedrock and direction of glacial drift to determine the nature of the adjacent deposits with a goodly degree of accuracy. This is a great help in the matter of future tests, as it gives a good idea of what can reasonably be expected from samples of material submitted from different sections. If construction is contemplated at a certain place we are able by means of tests made in conjunction with our survey to locate satisfactory deposits without further tests. We have also taken samples of sand from all sections of the State and tested them for their strength in cement concrete.

This acts as a great relief to our laboratory during the season of the year when it is busy making tests on asphalts, tars, Portland cement, etc.

Taken all in all, this survey has been of inestimable value. In consequence of it we are better able to plan our work, both as to the nature of material to be used and its availability. The work of the laboratory during rush seasons has been lessened and the conservation of road materials has been promoted.

Highway Department and Railroad Cooperation for Transportation of Materials.

A. G. Gutheim, Car Service Section, U. S. Railroad Administration.

THERE is perhaps no line of industry which, in the aggregate, suffered so much as a result of the curtailment of commercial transportation service during the war as did the road building industry and the industries naturally associated with it. This curtailment of transportation for road building was practiced from the very beginning of the war. In the latter part of April, 1917, when the carriers revised their car service rules in order to gain greater efficiency, they provided that open top cars should be furnished primarily for the transportation of coal, coke, and ore. The result of this was practically a prohibition of open top car service for stone, sand and gravel on many railroads, and this prohibition precipitated a complaint that brought the stone, sand, and gravel people to Washington and gave me my first insight into their side of the question.

That first difficulty in the early days of the war was patched up sufficiently to take care of the coal situation and the blast furnace situation, and at the same time give reasonable service to construction materials, and this continued throughout that summer. With the advent of fall weather, and with the greater war activity on the part of the country's industries in general, the pressure for coal became so strong that we had to face again the agitation for the prohibition of open top car supply for road building materials. This prohibition was counseled by the National Coal Association, then newly formed, which openly advocated and urged upon the Washington authorities that there should be no open top cars suitable for coal transportation furnished for any commodities other than coal until coal mines had first received all the empty cars they could load. Action along this line was held off, but in the fall of 1917 the situation became such that Judge Lovett, then Commissioner of Transportation Priority for the President, finally found himself in the position where it was necessary to cut off car supply for road building materials. Thereafter, and practically throughout the war, transportation for road building materials was greatly curtailed and the road building industry itself necessarily curtailed in consequence.

RULE WHICH GUIDES CAR SERVICE.

I recite these facts of history merely to preface the statement that the result seems to have been an impression gained among shippers of other commodities that whenever the open top car supply becomes short it is the perfectly proper thing to cut off car supply for road building materials. I want to say at this point, and to make it very definite and clear, that that has never been the viewpoint of the Railroad Administration, nor that of any individual railroad officials, so far as I know. It has been our rule in the commission on car service, and in the administration generally, to proceed always in full accord with the requirements of the Act to Regulate Commerce, that there shall be no unjust discrimination between commodities. Unfortunately, however, the present state of industrial unrest in the country has precipitated situations which have made it necessary to deviate somewhat from this principle. The point to be borne in mind now, however, is this: That we are practically in a state of peace, although, to be sure, in a somewhat disturbed state in our domestic industrial condition, and under these circumstances it is no more than just and fair that all commodities should share in the available transportation facilities upon a just, reasonable, and nondiscriminatory basis. That, I feel sure, is the rule which guides the Car Service Section and the Railroad Administration in their handling of the various problems that came before it, and I feel equally sure that that is the attitude which railroad men generally take in the disposition of their available car supply.

Coming now to the future, I think that the road building people should insist first, last, and all the time, that they propose to get this just, reasonable, and nondiscriminatory distribution of cars which is guaranteed them by law. That should be the basis of all your relations with the individual railroads and with any other organizations, Government or other, which have to do with the problem hereafter.

CENTRALIZED CONTROL OF SERVICE.

I had hoped that by the time of this meeting the railroad situation would have been so far settled as to enable us to know just what arrangements would be made by the carriers as to the future for centralized control of cars. By that I refer to the proposal which is still under consideration, that there shall be reestablished the commission on car service which handled car control in conjunction with the Interstate Commerce Commission for about a year preceding Federal control of railroads, and which, after Federal control, was taken over by the Railroad Administration as the car service section. Final decision of this proposition has not been rendered, but I think that I can say here that there is every indication that with the termination of Federal control, there will be in Washington some central organization of the railroads which will handle car supply generally throughout the country for the purpose of effecting the most efficient utilization of the equipment available, and for the benefit of the entire country. Certainly, if some such organization is not maintained by the railroads to work as did the old commission on car service with the Interstate Commerce Commission, then the Interstate Commerce Commission itself will undoubtedly have to handle the situation under the car service provision of section 1 of the act to regulate commerce, commonly known as the Esch car service bill.

I feel, therefore, that you can look forward with confidence to the opportunity of dealing on this general question with some central organization in Washington which shall have some control over the equipment which, according to all the information that comes to me, will in the next few years be in greater demand than ever before for the transportation of road-building materials. The particular point about this centralized control of cars is this: A great deal of your road building work is to be performed in one way or another in conjunction with the Federal authorities and through the administration of the Bureau of Public Roads of the Department of Agriculture. I take it, therefore, that henceforth we can look to the Bureau of Public Roads as a sort of liaison office between the road building projects and the State commissions and others, most intimately interested therein, and the central organization which controls car supply.

If the tonnage of road building materials to be handled in the next few years is anything like what is expected, it is my guess that there will be considerable advantage in having such a recognized point of contact, and I have not the slightest doubt that it will be conducive to a more efficient utilization of transportation facilities and better transportation service for the road-building people.

THE SUPPLY OF CARS.

Last July, when the Director General answered a resolution of the Senate with respect to the coal car situation, he pointed out that there were about 775,000 cars on Federal-controlled railroads of this country available for the transportation of coal. There have been some additions since, and when it is considered that some light capacity cars, not strictly suitable for coal transportation, are suitable for transportation of stone, sand, and gravel, it is probably fair to say that at the present time the cars available for the transportation of stone, sand, and gravel number in the neighborhood of 800,000. This does not mean, of course, that all those cars could be turned to the transportation of road-building materials, no more than it means that they could all be turned to the transportation of coal. They must, of necessity, be used indiscriminately for the transportation of that very heavy tonnage of bulk commodities which must necessarily be transported all over the country at all times. Principal among these are ore, limestone, and other commodities utilized in blast furnace operation.

This large number of cars, however, while it includes some increase during the past year from the number in operation previously, does not include much in the way of increase commensurate with the general increase of business over the past few years. That is the inevitable result of the restrictions upon car purchase necessary during the war for one or another reason, and the fact that many cars have gone out of service during the past few years incident to the very heavy use which was made of them on account of war necessity.

The opinion of most men conversant with the situation is that when a well stabilized condition of industry again develops there will be an extraordinary resumption of business, and a very heavy demand upon the railroads in consequence. Your extraordinary road-building program is, in part, one element of this increased tonnage that may be expected from the endeavor of the country to catch up with postponed peace-time employment. All in all, I think that you may look forward to the necessity, during the next few years, of railroads, shippers and consignees combines, making the most effective use of all equipment units available if the demand for the same is to be met.

EFFECTIVE USE OF EQUIPMENT.

You will observe that I put the obligation of making effective use of equipment upon the railroads just as much as on the shippers and the consignees. This is entirely proper. It is no more than right that the railroads, urging as they constantly do that shippers and consignee by every means shall utilize cars with the greatest efficiency, should do the same themselves. You should not hesitate, in your relations with the various carriers, where you find that they are wasting car days by neglecting to pull loads or to dispose of empties, to direct their attention to the fact and to follow it up until corrected. At the same time you should make every effort yourselves to make every car go the farthest. In a time of car shortage it is practically nothing less than a crime, regardless of shippers' rights under tariff provisions, to ship out cars which are not fully loaded to their carrying capacity. Likewise, it is nothing short of waste of the rankest kind to take two days to load or unload a car if you can do it in a day or less. We have seen numerous instances during the war period of consignees permitting cars to remain loaded on their tracks because they were short of labor and it was cheaper to pay demurrage than to take men from other lines of employment to put them to unloading the cars. Such consignees overlook the fact that every day's delay of that kind reduces the capacity of the railroad plant just that much, and inevitably, in the aggregate, tends in a material way to produce or increase a car shortage. That has been adequately proved to our satisfaction during the past few months when we have made a particular effort to cut down the detention of cars for unloading. A detailed record was kept of all cars of coal which remained on consignee's tracks longer than the 48 hours free time permitted by the demurrage tariffs, and it was not unusual to find on one railroad that the car days lost in this way were enough to have produced an additional 1,000 tons of coal on that railroad that day had the cars been released and put back to the mines, and this, you must bear in mind, at a time when the railroads were being criticized severely because of their inability to furnish car supply at the mines.

That brings me to another phase of the subject which is akin to what I have no doubt all of you men here have given much thought to, and that is the regularization of industry and its effect upon car supply. We in the railroad game have looked upon road building as a seasonal industry. One of the difficulties of railroading, as I see it, is that a good deal of the tonnage is seasonal tonnage, and the seasons run too much together. For instance, take this last year: Your road-building projects, through no fault of your own, so far as I can understand, were rather late in getting started. You had no more than started than the demand for coal started. We were then faced, in August, September, and October, with a demand for cars for both coal and road-building materials that was in excess of the available supply. Only a few months before, however, there had been weeks when the railroads were carrying 200,000 open-top cars a day in excess of all demands for them.

Our problem is to equalize that demand throughout the year and spread it over the whole twelve months. That is where the theory of regularization of industry will help the railroads, and, conversely, the regularization of industry will help industry itself by giving it more regular transportation. I am, therefore, an ardent supporter of the campaign to regularize industry, because I know that thereby we can regularize transportation demand, and the railroads can give better service than ever before and perhaps with less relative investment in equipment than has heretofore been necessary.

KEEP BUILDING PROJECTS GOING.

Along this line let me suggest that you should do your utmost to keep your building projects going, wherever possible, throughout the year. You should give the railroads which you expect to serve those projects all the advance notice possible, of what tonnage you expect to offer them, the points from which it will move, the average number of cars per day you expect to load, and the points to which it must be moved. Assemble this information and give it to the railroads at the earliest possible date in advance of the movement. You will probably find yourselves more certain of service if you are able to utilize what would otherwise be a return empty movement of cars to mines. I appreciate that it is not always possible to draw your raw materials from localities that will permit movement in that way, but where it can be done it will probably tend to assist you in car supply, should car shortage conditions develop.

You should load your cars as rapidly as possible, and to capacity, and you should urge upon your consignees that they should unload the cars and see that they are pulled out empty with the greatest rapidity. I feel sure that if all get together and each recognizes the obligation upon him to avoid transportation waste, that the job before us all can be met and met successfully

There will undoubtedly come times, however, when in some sections, because of the lack of sufficient open top cars on certain railroads, or because of an extraordinary road-building project in a community that does not ordinarily need open top cars, you will find a shortage developing which can not be cured by the individual railroad. You should handle this in the first instance with the individual railroad as far as possible. If that fails, however, I would suggest that the officials in charge of the project will probably be able, through communication with the Bureau of Public Roads, of the Department of Agriculture, or directly, if that is preferred by them, to obtain some assistance if assistance is in any way obtainable, through the medium of the central organization which will control cars in Washington. But the big point is to handle your difficulties to a conclusion, wherever possible, with your individual railroad, for in the last analysis your help must come from the men who handled the cars.

DISCUSSION OF MR. GUTHEIM'S PAPER.

Thos. H. MacDonald, Chief of Bureau of Public Roads: Without going too deeply into the questions raised by this paper, it seems to me that this association should take note of the fact that we are very likely to be faced with an increase in freight rates on road-building materials before we are in session again. And this question, as well as that of car service, seem to me to justify the establishment (within the executive committee perhaps), of a subcommittee that will deal with questions of that character. I don't know whether that is the way the association would wish to handle it, but whatever individuals are delegated to handle questions of this character for the association during the next year, in my opinion, will have to figure that as part of their public service.

G. P. Coleman, commissioner, Virginia: I agree with Mr. MacDonald that this question of transportation and freight rates is the most important question that is confronting the highway builders to-day, and that we must of necessity to protect the work which we have in hand, have some representatives from this association appear, or be in position to appear when necessary, before the proper bodies in Washington to represent our interests. I think all of us realize the importance of this question, but I am free to tell you, as a member of the executive committee, whether it is the wish of this association that it shall handle it, or whether it is the association's wish that the matter be handled by a special committee, we will do our best to see that it is taken care of.

Statement Submitted by the Highway Division of the Associated General Contractors.

Presented by R. G. Collins.

According to Mr. Thomas H. Macdonald, Chief of the Bureau of Public Roads, there will be available for highway work during 1920, $633,000,000. This is more than four times the amount of money that has ever been expended during any previous year for like purposes.

This enormous highway program is the direct result of the demand for better highways which has been made by the people throughout the United States. The responsibility for carrying through this program and obtaining these results rests primarily with you gentlemen as State highway commissioners and engineers to adminster and design, and secondarily with us as highway contractors to execute the work. We shall both be held to account if we do not produce a large and substantial mileage of highway in response to the enormous bond issues which have been voted by the public.

Although the production during the past year has exceeded all previous records, it is evident that if the mileage to be built during 1920 is to be even greater than that, careful consideration must be given to the experiences encountered during this last year of unusual performance.

In his very able letter to the State highway departments, dated October 27, 1919, Mr. Macdonald, Chief of the Bureau of Public Roads, points out four principal factors which must be taken into consideration if the production of highways is to be increased. These are: (1) Material supplies; (2) Shipping facilities; (3) labor supplies; and (4) contractors' organizations.

MATERIAL SUPPLIES.

1. Early letting of contracts: The first and most important consideration affecting the highway program for 1920 is an early letting of contracts. While this affects particularly the question of transportation and contractors' organization, it has its most significant bearing upon the question of material supplies. An early letting of contracts will enable the contractor to place his order for materials with the manufacturer at once and thus enable the manufacturer in turn to take advantage of all available seasonable weather in which to operate his plant. Again, contractors can take advantage of the supply of open-top car equipments during the months of February, March, and April, when, as pointed out by Mr. MacDonald, there is a large supply of idle equipment.

2. Estimating materials in stock piles.—But the advantage which thus accrues from an early letting is frequently offset by the heavy expenses and the large capital investment which contractors have been under because of the provision in most highway contracts that materials shall not be paid for until they are in place. The result is that the contractor aims to minimize the amount of time between the receipt of his materials and their actual use in highway construction as much as possible. This means that he is obliged to postpone the delivery of the materials until ready to use them, with the result that production and transportation of them is also postponed until the last minute. The obvious result of all this is a serious shortage of materials with consequent waste of time and loss of mileage during the very best days of the year. This whole difficulty could be avoided if county, State, and Federal authorities would estimate to the contractor aggregates stored in quantities on account of contracts let, including the cost of material and handling of all aggregates stored in stock piles. Some States have already included such a provision in the contracts. In attempting to meet this situation another State, however, is planning to adopt a method of procedure, which is most unsatisfactory to contractors. In this case, the State has agreed to pay the manufacturer for all materials delivered to the contractor on presentation by the contractor of the proper evidence and details of their delivery and cost; but several general contractors, who have highway contracts in this State have refused to take advantage of this method, which disclosed to public use details of their contracts with the manufacturers which they consider private. Others consider such a step only one removed from the situation where the State will furnish the material, a proceeding to which they are unalterably opposed.

To quote from a recent editorial in the American Contractor:

> One of the most valuable assets that a contractor has is his ability to purchase and secure delivery of materials. Expert purchasing ability is just as important a part of the contractors' organization as labor and methods of handling work. The contractor through experience, becomes an expert buyer and his ability in this respect is reflected in his bid. The contractor who can control the shipments and the delivery of his materials will submit a more attractive bid than he would if this control were to be taken out of his hands.
>
> If purchases of materials are controlled by the State, the people of the State will have to pay more for the roads and highways that are to be constructed. There is no question about that. The matter of control is the vital thing. The control of delivery which enables the contractor to obtain the materials when and as he wants them is absolutely

essential if we are going to have a sufficient highway construction. When the State furnishes the material it assumes a measure of responsibility for the delivery of that material, but if a shortage should occur, it would be an easy matter to show favoritism in allocating the supply. The State would also have to be prepared to meet a measure of financial responsibility for delayed deliveries. If the State furnishes aggregate the contractor will be forced to add from 10 to 25 per cent to his labor cost to provide for losses which he may incur in connection with the delivery of materials.

3. Use of local aggregates.—A third means of greatly increasing the supply of material for highway construction may be found by the adoption of the policy of using local aggregates wherever possible, and the encouragement of opening local pits and quarries. Such a policy will not only materially increase the supply of materials available for highway work, but will help relieve railroad congestion, reduce the cost of construction, and greatly expedite the work. We believe that such a policy should be followed even to the extent of modifying specifications as to tests of materials where necessary.

4. Inspection of materials at source.—Another consideration which should be given attention in discussing material supplies is the inspection of materials at the source. It not infrequently happens that materials taken from a source from which samples have been approved by those in charge of the work have been rejected when delivered to the job. While the engineer, or inspector, is justified in refusing materials which are not up to standard specifications, the contractor on the other hand is hardly to be penalized for delivering materials from a source already approved by the same engineer or inspector. The contractor is, however, forced to stand the loss which such a procedure entails in time and money. It also frequently happens that materials, such as cement, which is delivered to the contractor in carload lots, is held up for days awaiting the approval of the inspector. Both of these contingencies could be avoided, and the progress of the work expedited, if the materials for use on a contract were inspected at the source of production.

As has already been pointed out, the problem of insuring an adequate supply of materials is closely related to that of providing adequate shipping facilities. The real solution of this problem will come about if a proper supply of cars is maintained by the railroads. Measures which will reduce the demand for cars, or which will distribute the demand over slack seasons will help materially, but the solution of the problem is to have the cars available when they are needed. This does not necessarily mean that the number of cars available must in all cases be increased, but rather that the supply shall be used with the most intelligent regard for economical service. Both State and Federal highway engineers can do much to help the contractors secure increased car supply and better car service in particular instances, if they will recognize the importance of their positions in the State or Federal administration in securing proper action in regard to transportation facilities as it relates to road work.

CONTRACTORS' ORGANIZATION.

The problem of carrying through the tremendous highway program which has been outlined depends even more upon the contractors' organization than it does upon material supplies. Material will ultimately arrive at the job, but without the adequate organization to put them into place and to get the work done, no great advance over the highwater record of 1919 can be expected. Until very recently, it has been an outstanding characteristic of highway construction that large contractors have not been particularly interested in highway contracts. Unless these men, with their large organization and capital, with their adequate equipment and well organized force of men to handle big projects, are encouraged to take part and find a share in that program attractive to them, large parts of work are bound to remain uncompleted.

To bring these men into the work the following suggestions are offered:

1. Let contracts in longer sections in one contract extending over longer periods of time than one season; and let such contracts include all the work on any section, including grading, paving, bridges, culverts, etc.

2. Let contracts only to responsible contractors who will show the qualifications sufficient to perform the contract as stated, careful consideration being given to the contractors' organization, equipment, past performance and financial responsibility.

3. Safeguard highway contracts from unnecessary risks, such as forced increases in freight rates, time lost bidding on jobs which do not go ahead, tying up of proposal guarantees and other losses incident upon delay in awarding contracts, unlimited responsibility on the part of contractors, unreasonable provisions of maintenance of highway after completion, retention of unnecessarily large percentage of payments, lack of specific information in plans and specifications, and inadequate amount of time allowed for studying them, needless refinement insisted upon by inexperienced inspectors, etc., etc.

If our conference could result in providing some adequate consideration of these three considerations, the problem of contractors' organizations to handle the enormous highway program would be solved.

AN ADEQUATE SUPPLY OF LABOR.

When the problem of attracting sufficient able contractors' organizations to undertake highway work is solved, the question of adequate labor supply will solve itself, for with better equipment, and an able organization, forces of labor can be quickly brought together and utilized to greater efficiency. The right sort of contractors' organizations can also supply and keep the right kind of labor, because they will maintain the right sort of conditions to help good labor on the job.

SCOPE OF CONTRACT.

The chief reason which has deterred the majority of large contractors from undertaking highway work is the scope of the contract. Adequate equipment for highway construction undertaken on a scale which would be attractive to a large organization is too expensive an investment for a single season's contract on a small stretch of road.

In view of the unprecedented shortage of labor it is obvious that the construction program which has been outlined can only be carried through by substituting machinery for labor. When it is recognized that the special equipment necessary to construct 8 to 10 miles of concrete highway in one season will cost from $75,000 to $100,000, you will realize the enormous investment which will have to be made to carry out under existing conditions the program which the public demands.

These factors should be given a great consideration in determining the scope of the contracts and the fitness of the concern to whom the contract is to be awarded. If each contract were let in larger sections, extending over longer periods of time than a single season, larger contractors would find it worth while to devote their organizations and equipment investment necessary to large scale highway construction.

In this connection it seems almost unnecessary to point out the effect of the tendency in some States to let different parts of the work in the same section to different contractors. Large contractors with large organizations are not interested in highway work where the grading is let to one man, the paving to another, and the bridge and culvert work to still others. He is equipped and organized to handle a job from start to finish, and his whole force is coordinated with that end in view. To engage one part of it only is to enforce idleness on the others and to disrupt his organization. Again, the responsibility for coordinating his organization and work with that of other contractors frequently involves greater risks and losses in time and money than these contractors care to bother with. Especially is this true where there is a separation of such parts of the work as grading and paving. General contractors are organized to handle large contracts as a whole and if the advantage of their large scale organization is to be had in highway work, highway contracts must be let as a whole. The saving to the State in better highways and in greater mileage produced will more than offset the apparent saving which appears on paper in totaling up separate bids.

RECOGNIZING RELIABILITY IN AWARDING CONTRACTS.

There is, however, a second consideration which has almost as great a bearing on the question of interesting large and able contractors' organizations in highway work and that is the elimination of the unreliable and irresponsible contractor as a factor of comparison in awarding contracts. Reliable and competent contractors will not waste time submitting bids in highway work when they realize that no consideration will be given to their organization, equipment, past performance, financial responsibility, and general ability to perform the contract. Of all types of construction, highway work offers greater possibilities for the "fly-by-night" contractor to compete on an apparently equal footing with the responsible man, than almost any other kind. The characteristics of public work enhance these possibilities. As a result, unless some of the obvious factors such as have been mentioned are given greater work with the actual price figures, first-class men will not bid on highway work. Some method must be developed for giving contractors assurance that those factors will be considered if the ablest men are to be attracted to highway work. The obvious saving of a few dollars as between the low bidder who does not know his business and can not perform the work satisfactorily and the contractor who knows his costs and guarantees an A-1 performance in reality exists only on paper. It can be set down as fundamental that more mileage and better highways can be produced by better contractors, and better contractors will be interested in highways only when the quality which enables them to produce such results is given weight in comparison with men who can bid but can not perform.

ELIMINATING UNNECESSARY RISKS.

It is probable, if contractors could be assured of contracts whose scope would interest large organizations and capital investment and a due recognition of quality and performance as well as bidding price, that the main obstacle to interesting large contractors in highway construction would be overcome. But even then highway construction would not be all smooth sailing. There exists at present in highway work, due to the fact that it has practically grown up overnight, various risks and undeveloped elements which make contracting in this field less attractive than in the more developed lines of construction. While individually these are of less importance, together they have a very important bearing on the interest which contractors with large and capable organizations take in highway work.

The procedure and practice surrounding the letting of highway work is in some States still in the stage of development. Proposals for highway work are frequently requested when the details of financing have not been taken care of. As a result the letting is delayed if not indefinitely postponed, and the proposal guarantees held up and time lost all around. Bids are rejected in highway work for any reason under the sun, and the contract let to some one else who will cut under the figures announced.

Sometimes plans are not delivered on the work to be let until a few days before bids are asked for, and then frequently the plans give only the most meager information. On the other hand, needless refinements in the specifications are sometimes insisted upon by inexperienced inspectors when the progress of the work demands a reasonable interpretation.

According to some contracts the contractor's responsibility for all easements or for the maintenance of the highway, even after it is turned over to the public, seem almost unlimited. At the same time the retained percentage on highway work is frequently away out of proportion to the actual necessity for safeguarding the State, to the serious inconvenience and loss on the part of the contractor.

In all these points, the contractor is not asking the highway departments to relieve him of the risks for which he is paid to assume, but rather to relieve him of those risks for which he is not by any right responsible.

One of the most obvious of these details which have served to keep conservative contractors away from road construction is the uncertainty of freight rates. Fortunately some State highway departments have already made provision to allow for such increases in freight rates, but the majority have still to make adequate provisions for reimbursing the contractor for increases in freight rates which are ordered after he has signed his contract.

Where bids are rejected due to difficulties in financing or for other good and sufficient reasons, the low bidders should be reimbursed at least one-half of 1 per cent of the average of their bids toward their expense.

PLANS AND SPECIFICATIONS.

In order to secure responsible contractors who will make responsible bids on highway work, time to make up an intelligent bid must be allowed. A reasonable length of time, say 3 weeks, can be established as the minimum time between the date plans and specifications are furnished and the date bids are to be submitted.

It is surely not an unreasonable request also to ask that plans and specifications show the limits of the right of way, the amount of grading to be done, the location and size of culverts, bridges, etc., with a reasonable amount of accuracy; and, furthermore, it seems reasonable also to suggest that if there are any material changes in the plans furnished to the contractor after the contract is awarded, that the contractor be compensated for the extra cost and delay on account of making changes. Such suggestions as these provide no special favors for the contractor; they are simply checks which probably safeguard the contractor against loss of time and money due to lack of reasonable consideration for his interests on the part of the officials in charge of the work.

If refinements in specifications are shown to be unreasonable, joint consideration by contractors and engineers in conferences like this should remove them. Both contractors and engineers should urge the proper authorities to appropriate sufficient funds to secure the services of competent inspectors by paying them a wage equal to that paid the same class of men in other industries.

LIMIT THE RESPONSIBILITY.

We do not think it unreasonable to ask that the contractor's responsibility and liability be limited in several respects on highway work, and we believe that to do so will help encourage responsible contractors to undertake it. The practice adopted in some States of providing easements to contractors for special roads and bypaths maintained for public convenience might be adopted to advantage by other highway departments. Again, to ask contractors to be responsible for the maintenance of roads after they have been opened to public use is to make them responsible for the plans, specifications, and inspection which it is the highway department's duty to assume. If the plans and specifications are sufficient to get a satisfactory road, and if the inspection is properly done, it can be rightly assumed that a good road has been constructed. To extend the contractor's responsibility, as in some States, to a year after the completion is sufficient to drive any reasonable contractor from highway construction. Each section of highway work, as it is opened for public use, should be accepted at the time paid for in full.

PAYMENTS.

The question of payments, beginning with the return of the proposal guarantee and including the payment for work done, is a problem which warrants more consideration if highway contracts are to be developed to their greatest efficiency. The recent clause adopted in Minnesota solves some of these difficulties. According to its provisions, all contracts are to be awarded within 10 days after the date of the proposal, and all proposal guarantees, except that of the successful bidder, will be returned within 3 days following the award of the contract. Should no award be made within 10 days, all proposals will be rejected and all guarantees returned.

In making progress payments on work, we believe that monthly or semimonthly estimates should be based on 100 per cent of the work done, with a sufficient percentage retained to protect the owner. This retained percentage should never exceed 10 per cent and should stop when it amounts to 5 per cent of the total estimated amount of the contract. Large contracts soon run into big money and partial payments based on estimates that are reduced at every step as they go down the line, and retained percentages which exceed reasonable limits soon find the contractor with large investments, not only in organization and equipment but also in State highways, perhaps the last place in the world he wants it invested. The Engineer Corps of the United States Army follows such a plan of retained percentage on their work and finds it very satisfactory. Similarly, the same plan may be applied to the reduction of the amount of bond necessary as the work is completed.

FORCE ACCOUNT WORK.

Payment for force account work frequently is a cause of friction in highway work. The clause recently adopted by the State highway department of Minnesota is worth consideration in this connection. Paragraph 33 of the Minnesota specifications entitled "Force account work" has been changed to read as follows:

All work done on force account basis will be paid for in the following manner:

(*a*) For all labor, teams, and foremen in direct charge of the specific operation, and such other expense as is directly a part of the cost of the work, the contractor shall receive the current local rate of wage, to be agreed upon in writing before starting such work, for each and every hour that said labor, teams, and foremen are actually engaged in such work, to which shall be added an amount equal to 15 per cent of the sum thereof.

(*b*) For all materials used the contractor shall receive the actual cost of such material, including freight charges as shown by original receipted bills, to which cost shall be added a sum equal to 15 per cent thereof.

(*c*) For any machine, power, tools, or equipment, including fuel, lubricants, which may be deemed desirable or necessary to use, the engineer shall allow the contractor a reasonable rental price, to be agreed upon in writing before such work is done, for each and every hour that said tools or equipment are in use on such work, to which sum no percentage shall be added.

ENGINEER'S ESTIMATES.

With the question of payments is closely connected the subject of the engineer's estimate. When highway contracts are let at unit prices, the engineer directly in charge of the work feels, nevertheless, that the total cost should correspond as nearly as possible with the costs shown on his original estimates. While both contractors and engineers recognize the fact that it is almost impossible to prepare plans and specifications that are so perfect that they do not have to be altered after the work is started, thus affecting the original estimate, county boards and other officials who are not experienced in engineering and contracting are not so ready to acknowledge the engineer's estimate as an approximate figure. In making adjustments on cost plus work frequently the result is that basing his stand on this estimate the local engineer attempts to make a lump-sum contract out of a unit-price job. State highway officials can do much toward educating local engineers in regard to this subject and help secure much more reasonable consideration of work done on a cost-plus basis.

We strongly recommend that your association take definite action by authorizing your executive committee to appoint a permanent committee to act jointly with us in improving existing conditions and unite our efforts to fulfill the expectation of the public.

The best evidence that these suggestions are within the realm of possibility lies in the very fact that in response to the invitation of your association the Associated General Contractors, representing the ablest contractors in the country, have called highway contractors together from all parts of the country to discuss these problems and are present here to-night in large numbers as evidence of their good faith in talking them.

DISCUSSION OF PAPER BY MR. COLLINS.

A Member: I would like to ask Mr. Collins what size contract he would consider best for the contractors to figure on. I am asking for this reason: If the contracts are large, there are very few contractors who will bid on the work. Certain work we have on hand now is made up almost entirely of large contracts; very few of them as they stand today figure at less than $200,000. The question in my mind is whether we shall cut them into smaller projects, say of $100,000 each, or leave them as they are. We have one nearly $500,000. What I want to get at is what the contractor would consider an inviting project for bidding.

Mr. Collins: Well, I don't think any large contracting organization would want to go down there for anything less than $200,000. I think the question of the handling of contracts depends largely on the locality in which it is to be built. The 4-mile contract for one section is pretty big, and the 20-mile contract in another section is no bigger. I think it depends on that and the quickness and manner in which local organizations are kept and the quickness with which you can get through the job. It is not so much a matter of cost as of quality.

F. F. Rogers, State Highway Commissioner, Michigan: If I might supplement, I might suggest a plan in use in some States now—that is, taking bids in short sections of, say, 10 miles, and accepting combination bids for three or four sections. In this manner the contractor of a large organization can bid on the larger section and the small individual contractor can bid on the smaller section. That would give a chance to compare the bids, and, as has been found to be the case in a number of instances, the bid of the larger contractor on the combined sections may be was less than the bid of the small contractor on the small sections.

Mr. Collins: Right there I would like to add to one point I tried to make plain in the paper. People want roads, and the total of small bids on paper may be less than the total of a larger contractor's bid. The question is, which is the better bid for the people, in view of the fact that they want roads. I think such things ought to be taken into consideration equally with the mere figures.

Mr. Rogers: Our experience in Michigan is that even our best contractors are unable to finish more than 5 or 6 miles in the season. If we have 25 miles in one project and we don't split it up into 5 or 6 sections we have either got to have a contractor who will put on 5 or 6 entities or have 5 or 6 contractors on the job to get it done in the season. There is some tendency sometimes with the larger fellows to sublet the grading, the culverts, and some of the other work, so that in reality we have just as many irresponsible fellows to deal with carrying our construction as we would have if the other men got on the job who could guarantee to complete 5 or 6 miles a year. As a matter of fact we have only had two contractors who have completed 5 miles and upwards of roads this year, where we have about half a dozen that have fallen down on that much.

Surveys and Plans and Suggested Changes to Meet the Shortage of Engineers.

P. St. J. Wilson, Chief Engineer, U. S. Bureau of Public Roads.

THE pamphlet issued April 28, 1917, from the Office of the Secretary of Agriculture and entitled, "Standards Governing the Form and Arrangements of Plans, Specifications, and Estimates for Federal Aid Projects," by implication presents the ideas of the Bureau of Public Roads as to how surveys and plans should be made, although the word "surveys" does not occur in the title. This pamphlet was prepared by the Bureau of Public Roads in cooperation with a committee of this organization. At the end of the first season's work these requirements were discussed at some length at the Richmond meeting of the association and as a result amendments Nos. 1 and 2 were promulgated. At the end of the second year the State highway departments were requested to criticize certain amendments to the rules and regulations and to the standards, and as a result amendment No. 3 to those standards, approved March 18, 1919, was promulgated, and at that time it met as far as possible all of the major criticisms made by the State highway departments. Some of the criticisms made by individual States were so conflicting as to make it impossible to meet them all.

EXISTING STANDARDS SATISFACTORY.

Upon the assignment of the present subject for my presentation to you at this meeting, and with the thought in mind that the experience of the present season might have clearly developed further suggestions for modification of the existing standards, a circular letter was addressed to the State highway departments of the several States, asking for an expression of opinion as to the probable shortage of engineers and for suggestions as to further modifications of the requirements for plans and specifications, having such probable shortage of engineers in view. Replies have been received from 30 States. From these replies it is gratifying to report to you that the present standards are apparently satisfactory to a great majority of the States, and it will be a pleasure later to support this by quotations from the letters received.

Six States—Arizona, Michigan, Idaho, South Dakota, Oklahoma, and Wyoming—make suggestions that the plotting of cross sections might be omitted. Otherwise, there are few suggestions for reduction of the standards, except in minor details. It is felt that a thorough study of the amendment of March, 1919, to regulation 5, section 8, particularly of the amendments regarding the scale of plans and profiles, and of the requirements under cross section will convince those who object to plotting cross sections that considerable relief is possible under the existing regulations. For instance, it seems to be the impression of some of the above-mentioned States that cross sections must be taken every 100 feet, whereas the regulations reads: "For original plans, cross sections shall be taken at such intervals as may be necessary to show accurately the character and extent of the intended work." This makes no arbitrary limit of distance between cross sections.

Sixteen of the 30 State departments replying to the above-mentioned inquiry stated emphatically that they desire no changes in the existing standards.

SUGGESTED CHANGES CONSIDERED.

From the discussion submitted by several States, two definite minor points in the preparation of plans deserve consideration. First, that some relief is desirable in the regulation with respect to the ratio of the horizontal to the vertical scales on profiles. The regulation, as it now stands, requires the ratio to be 1 to 5 or 1 to 10, and in the case of 200 or 400 foot horizontal scales it is now suggested that 5 feet or 10 feet to the inch vertical be permitted. This suggestion from Arkansas is a good one and will be immediately taken under consideration for adoption.

Ohio suggests that where the stationing of both ends of the vertical curve is shown the length of vertical curves be not required on the profiles. This seems an unnecessary duplication and might be omitted. Another suggestion comes from several States that temporary obstructions like wire poles, fences, etc., may be omitted. While the Bureau of Public Roads has found this information very useful in some of its own work, it may not be in all cases, and the requirement might be made optional.

In regard to the criticism of Minnesota, I feel that we are not yet ready to concede that what is known as a preliminary plan is all that is necessary at the time of awarding the contract on a unit basis. Information in reasonable detail as to requirements, as well as a close approximation of quantities, are necessary to the contractor in order to enable him to bid intelligently, and I gather from a number of the letters recently received that the cost of acquiring such detail is more than compensated for in resulting prices. I should be interested in a development of his method should Mr. Mullen do that in his discussion of this paper.

EXPRESSION FROM STATE DEPARTMENTS.

As you will doubtless be interested in the opinions of the several States replying to my letter of October 28, I quote the opinions expressed regarding the present standards.

Arizona.—* * * Considerable reduction in the work * * * might be secured if the platting of cross sections were eliminated from the plans necessary to submit with the project agreement.

We believe that estimates would be much closer from slopes and center readings or from actual computation than by use of the planimeter, and that this work could best be done by the engineers overseeing construction rather than the location.

Arkansas.—* * * In our opinion the requirements as to the details to be shown upon the plans are probably too strict, and among the points that may be mentioned are the requirements for showing property owners, the location of unimportant features, such as telephone poles, fence lines, and high and low water marks of small culverts where ruled profile paper is used.

In regard to scales, we still have many requests for scales other than those permissible at present, and it is true that in our State where more than one-third of our area is very flat, the scale of 200 or 400 feet to 1 inch horizontal and 5 or 10 feet to 1 inch vertical would be preferable, as the topography is such that frequently we find a fall of only 1 foot to the mile in our grades. Where the standard scale is now used many of the engineers are forced to make a set of working drawings for the contractor to a 400-foot scale in order to show the information in a condensed form for use in the field. This, of course, would not apply to closely built up sections, such as we find nearer the larger cities, but it should be remembered that nine-tenths of our roads are in the rural sections and on these roads there are very few topographical features to be shown.

Connecticut.—With reference to the suggestions concerning the general subject of Federal aid, much might be said regarding the duplication of work now performed by the State departments and the Bureau of Public Roads. If it were possible for your district engineers to pass finally and at once upon the surveys made by the State highway departments, without making it necessary to have a reinvestigation at Washington, it would seem to me, it would be of great value.

SALARY INCREASES THE SOLUTION.

Colorado.—An increase in road work as well as in railroad and irrigation projects I believe may be looked for during the coming year and will undoubtedly call for a large amount of engineering assistance. I believe it will be absolutely necessary that schedule of salaries paid for the different positions be increased substantially in order that men may be attracted to this line of work. As far as the best method of making our surveys and plans is concerned I have no radical changes to recommend.

Georgia.—* * * It is doubtful if anything could be omitted without in the long run causing some additional work to the project engineer.

Idaho.—I have one suggestion in regard to the preparation of plans which would materially cut down the time and cost in their preparation for Federal aid projects and that is the method of furnishing the department with plotted cross-sections with each and every 100-foot station on the line.

Illinois.—We are very much pleased in this department with the form of plans specified by your office. We are convinced after having tried the size of sheet, scales, and general practice that it is much superior to that which was formerly in use generally throughout the States.

I am convinced that no expense should be spared to make the surveys and the resulting plans carefully in order that difficulties during construction may be avoided.

Indiana.—We are experiencing very little difficulty with our plans in so far as the Bureau of Public Roads is concerned. I doubt if any modifications can be made that would materially help us. Since the rules and regulations have been revised, I believe there is very little called for that is nonessential.

Iowa.—In reply we wish to say that we have no criticisms to make of the requirements of the Bureau of Public Roads with reference to surveys and plans.

Kentucky.—I seriously question whether it would be advisable to curtail the amount of information that we now require on our plans.

Maine.—I do not know how satisfactory surveys and plans can be made except as already outlined by the bureau.

Massachusetts.—So far as making changes to meet a possible shortage of engineers is concerned, I would say that I do not see how we could make any material changes where it is necessary to make definite lines of location for the taking of land for layout,

Michigan.—It might be possible to leave off from the plans, cross-section at every station using only typical cross-sections, say every thousand feet or more where there is very little change in the contour of the land.

With this exception the Federal Aid plans are not more complete than we are making for all of our State trunk-line roads.

MINNESOTA'S SUGGESTION.

Minnesota.—I have your letter of the 28th instant, and replying would say that in my judgment the engineering work could be made less expensive and more progress accomplished in the starting of work, if your office would modify requirements as to perfection of detail on the preliminary plans. As a basis for consideration of this matter, you will first have to come to a conclusion that the preliminary plans, at best, are only made for the purpose of determining the general layout, and in the construction of substantial improvements as are being built in this section of the country, it is expected that plans will be revised by the resident engineer on construction as the work proceeds. This being granted, it is a waste of time for the engineer to spend a great deal of effort in trying to arrive at perfection in the preliminary plans, so long as his general layout is correct. In this State our work is let on a unit-price basis, the contractor being paid for grading on the actual excavation measured by the engineer at time of construction. When this is done the detailed accuracy of figuring quantities on the preliminaries is practically lost. If, however, we are to continue in the endeavor to have a perfect set of plans prepared before the letting of the work, it would then be better to let the work on a lump-sum basis and place an instrument man on the work instead of a resident engineer, forcing the contractor to build according to plans, regardless of local conditions, as they develop. To sum this matter up, I would say that a great deal of time could be saved and the engineer's situation relieved considerably, if your office would omit the detailed checking of plans, excepting as to general layout of the work, leaving it to the State highway department to execute the work according to the general plans and return to you a final plan and profile showing what was actually accomplished on the project. This is the method which is followed on State work in Minnesota and is very satisfactory.

New Mexico.—There is one hardship imposed by the Bureau of Public Roads which possibly could be eliminated and that is that the bureau demands the State highway department advise them of any changes to be made on contracts which incur an increase in cost before work is started. This could be eliminated if such increases or decreases (changes) were put on the final plans and estimate at the time they are sent to the Bureau of Public Roads.

USE STANDARD ROADWAY SECTIONS.

New York.—The more extensive use of standard roadway sections and structures are to be encouraged to accompany contract plans as they tend to eliminate repetition and by the use of same necessary quantities become familiar to the designer.

North Dakota.—* * * having quite completely discarded the idea of machine or turnpike work, we have no special fault to find with the standards governing the execution and arrangement of plans and estimates as required by your department.

Ohio.—In answer permit me to say that in general the requirements for State aid are the same as for Federal aid projects and I can see few changes which could be made tending toward simplifying the preparation of plans.

Oklahoma.—* * * I have advocated from the start the preparation of simpler plans occupying much less space than the standards of your bureau and using symbolic alignment and other methods of shortening such preliminary work and reducing plans to more compact size.

COMPLETE INFORMATION IN PLANS.

Pennsylvania.—From my viewpoint, it would seem undesirable at this time to make any changes in your requirements which might lead to the prepation of plans which would not give complete information to the contractors. In view of the present high prices, I do not think it desirable to consider simplifying requirements. I believe that if our road plans contain full and concise information, not only as to location, grade line, cuts, fills, bridges, suitable material supplies, railroad sidings, streams, etc., that we will get more reasonable and lower bid prices.

Rhode Island.—We have plans and surveys complete for a considerable mileage of construction and reconstruction to be done next year.

South Carolina.—At various times during the year we have kicked among ourselves on the amount of detail required by the Bureau of Public Roads, yet after going over the entire methods and processes now being used we found that we were unable to devise a better scheme than is now being required by the Bureau of Public Roads. This is specially true in view of the fact that we are finding it necessary to use many young, inexperienced engineers. I, therefore, say that we are unable to make any recommendations toward the improvement of the present method of handling surveys and plans.

South Dakota.—Careful analysis of the present requirements of the Bureau of Public Roads for preparation of plans will convince anyone well informed on these matters that the requirements, on the whole, are no more than the same should be * * *.

There is just one requirement regarding which we feel like offering any suggestion, and this suggestion probably will apply with more force for a State new in road work like South Dakota, * * * than for older States where their principal efforts and expenditures are centered on surfacing.

We believe it would greatly accelerate the preparation of plans if the earthwork quantities could be based on estimates made from a center line survey.

Tennessee.—* * * I can really think of no changes to be made at this time. I believe that the surveys and plans should be as complete in every detail as possible and that the requirements now made are not in any sense excessive.

Washington.—In reply I wish to advise that we have experienced no difficulty whatever on this account nor on account of the requirements of your bureau, as they now stand. In fact we have secured the fullest cooperation on the part of your district office in Portland, Oreg., as well as the bureau at Washington, D. C., in all matters pertaining to the initiation and execution of Federal aid contracts.

West Virginia.—It is believed that the present requirements of surveys and plans, demanded by the Bureau of Public Roads, are as simple as they possibly could be, and yet meet the requirements which should be embodied in any such plans. It is believed that the present arrangement of plans in some respects even falls short of its purpose. The plans should show the balance, with respect to cuts and fills. It is believed that more time should be spent in surveys than we are able to at present. It has been found by experience that where the surveys have been made more carefully, that the subsequent construction of the road has been materially cheapened. This statement is more especially true in the mountainous State of West Virginia.

INDORSE REQUIREMENTS IN PLANS.

Wisconsin.—The Wisconsin Highway Commission endeavors each fall to secure a large mileage of surveys in order that the plans might be worked up during the winter months when it is impossible to carry on field work. I note that you state in the last paragraph of your letter that "it is believed a large amount of survey work should be completed before the next working season begins * * * ." This has always been our policy and due to that fact alone we are able to maintain the same force of engineers from one end of the year to the other and in that way are not bothered with the necessary engaging of a large force of engineers at the beginning of the season and the subsequent laying off of those same forces at the end of the season.

* * * I believe that the standards embodied in your standard plan are of such value that none of them can be eliminated. I have felt at times in the past two years' experience with Federal work that some of the requirements were perhaps unnecessary, but after working under your standards for two years I have changed my conclusions on this point, and even though I have sat down and made a study of the plans with a view to cutting down all the work, I have been able to find nothing that could be omitted without affecting the value of the plan.

Wyoming.—* * * I believe that our work on plans for Federal aid projects has been so developed as to keep the costs of this work as low as could be expected under the present regulations.

The cost can be reduced and consequently the number of draftsmen required be reduced by less rigid requirements as to cross sections and estimates. The cost of platting cross sections for every station or oftener, is high in comparison with the rest of the work. If the bureau would not require us to furnish cross sections, but depend on the highway departments to furnish satisfactory estimates, using whatever method that they should see fit, to make these estimates, a very material saving will result, and I desire to strongly urge that this change in your requirements be made.

THE SUPPLY OF ENGINEERS.

With reference now to the question of the apprehended shortage of highway engineers and surveyors, replies to my letter of October 28 from 29 States present interesting data. Seven States, Arizona, Colorado, and New Mexico in the far West; Kentucky, Ohio, and South Dakota in the Mississippi Valley; and New York in the North Atlantic States, report an anticipated shortage. Arkansas, Michigan and North Dakota in the Mississippi Valley indicate a probable shortage, as also does Wyoming. Four States, Alabama, Illinois, South Carolina, and West Virginia, are either silent or undecided, and eight States reply that no shortage is indicated. Iowa, Maine, Minnesota, Oklahoma, Pennsylvania, Washington, and Wisconsin indicate that there will probably be no shortage. So that of the 30 States, less than one-half indicate any anticipated shortage of engineers.

In general, the sentiment reflected is that the real shortage exists in the class of resident or constructing engineers and in some cases in the class of designing engineers. It is admitted that the better and more experienced men in general should receive larger salaries than now prevail. New York submits a schedule of salaries revised upward and effective November 1. Idaho regrets its inability to pay sufficient salaries under the law.

Notable results are reported from several States in the matter of accumulating sufficient surveys in the late fall to carry a considerable force through the winter on design work. It is quite apparent that a distinct effort has been made to prepare for the coming season's construction by the expediting of surveys in many States. Some of the States report that they will endeavor to do a considerable amount of surveying during the winter. A number of States indicate that their difficulties in securing engineers have been largely solved by the planning of their work so as to keep a permanent force throughout the year. From the far West reports from our district engineers and two of the State highway departments indicate that should a resumption of railroad construction occur an acute shortage of highway surveyors may result, since at present a considerable number of railroad engineers are engaged in highway work.

Apparently, in general, there will be a supply of highway engineers sufficient to handle the work for which contractors can be found in a large proportion of the States. It is apparent from several replies that a shortage of contracting strength and of material supplies is more feared than a shortage of personnel.

A good suggestion comes from New York in the matter of making the maximum use of computing machines, tables, etc., in all calculations for highway design. There is no disposition evident to try to meet any anticipated shortage by a reduction in the quality or present standard of plans and surveys. It is recognized that highway work now costs nearly twice as much as it did four years ago and that now more than ever the plans must be complete in every detail to clearly set forth to the contractor for what he is to be paid. There is evidenced a desire to emphasize that we should not try and economize on the 10 per cent engineering item of the cost and take chances with the 90 per cent item of the total bill for the highway.

DISCUSSION OF CAPT. WILSON'S PAPER.

J. H. Mullen, chief engineer, Minnesota: I think perhaps a wrong impression may have been obtained—not intentionally—from the paper, in which Capt. Wilson stated that what is known as a preliminary plan is all that is necessary at the time of awarding the contract.

Minnesota doesn't advocate only what is known as the preliminary plan. On the contrary we have for the past six years used practically the same method of preparing our plans as that required by the Bureau of Public Roads at the present time. It is somewhat different in form but in general it is the same. We found several years ago that on the large grading work that we had in our State it was necessary to give the contractors very complete information as to the basis of their bidding. We have a bond law that permitted us to lay out our work in long sections. On two different roads the contracts were 70 miles long in each case and on many roads they were some 40 to 60 miles. That was a special assessment law. When we started in we found we had to have some really definite basis for awarding the contracts. So we made very complete cross sections of the work, drew up the cross sections, and furnished them to the contractors; and I believe that is absolutely right. I wouldn't recommend that the requirements in that respect be waived at all or that the wires be let down in that respect.

There is a little different method used in our State in preparing the cross sections. We draw the cross sections of the working profile. That is, it is not the actual profile that is submitted as part of the plans, but we draw the profile on the upper half of the cross section, with the cross sections below in that particular location, which we think is a very good thing because it gives the man who is working on the design an opportunity to compare right before him the profile with the cross section. Of course the profile is not inked in; it is just a pencil profile used as a working profile. But we prefer to submit those cross-section sheets in that form with that temporary profile in pencil. We think it is somewhat a saving and we believe it works out to advantage on the job.

We go perhaps a little farther in some of our design work than is required. This is said just to clear the impression that we might want to cut down the plan requirements. We use a small-scale profile and require all our resident engineers to submit progress profiles on these small-scale profiles. Every month we receive a progress profile on every job showing what was accomplished. We use a color system to do that. That is, for the various months we use yellow, blue, green, red, and so on to show the progress of the work. It is mighty convenient, doesn't take a great deal of time, and gives us a good check.

CHECKING OF THE QUANTITIES.

The point that I tried to make in my letter to Capt. Wilson is that we do not consider that it is to the interest of the job to put too much refinement into the checking of the quantities. That is really the point. We believe that work should be checked as to the design, the grades, balancing of quantities in general, and the alignment of course should be checked; and we are very glad to have any suggestions that will better our layout as to grades and alignment.

But I believe there is a danger in the Bureau of Public Roads (the same as in our own departments in dealing with county engineers), to build up a little organization inside. I know we have had that to fight in our own department. You start checking work, put some one in charge of it, and that becomes the all-important feature of that work to that man, and he immediately begins to build up on it. As long as the quantities on the preliminary plan are reasonably accurate and are accurate enough to base your grade lines on, that is all that is really required, because all the State highway departments make their pay quantities on actual measurement of quantities moved, instead of on the preliminary.

So my point was, when the quantities reasonably check the plans should be approved without sending them back for remeasurement when perhaps the difference may be in a personal equation, the difference in the way of measuring the sections.

That doesn't seem to be very important, but it does gum up the work, especially in the spring when we all have more or less work hanging over us. We try to organize our work in such a way that we can use the survey organization for designing in the winter time, but that can not be done as well in practice as in theory. We find every spring we have a whole lot of work to jam through, make the surveys and plans and let the contracts after the snow leaves, really after the construction season opens. So that on that work it is very difficult to get the plans precisely according to requirements.

The requirement that changes of design be submitted to the department for approval I think should be omitted. Of course I imagine a good namy States do make changes and then submit them to the district engineer without saying whether they have been made or not, asking for approval after changes. But really the intent is to have all changes approved before being made, which I don't think is practicable when we have a great deal of grade work.

I don't know of any other way that we can meet the shortage of engineers which is claimed to exist. We do not find there is a shortage of engineers up in Minnesota. We have a large number of railroad engineers up in that locality and we can draw from that source, but we will have to increase the salaries. The only danger we have is that they will enter other lines. It reverts back to the same situation that has been expressed here several times, and that is, we will have to pay more money if we are to interest the best kind of men in the work; and if we so interest the best kind of men there will be no shortage of engineers.

MUST MAINTAIN THE STANDARDS.

Col. W. D. Uhler, chief engineer, Pennsylvania: In reference to the remarks I have heard relative to doing away with some of these standards, I might say that if we attempt to do that and at the same time carry out a large program of construction we are bound to run up against a wall. We have been through times where we had a hundred miles of work and we did finely. Now that we have 3,200 miles of construction work on our hands, we find we can not take too much care in the preparation of plans and specifications.

As an illustration: If we attempt to do what some States are talking about, putting $30,000,000 or $40,000,000 worth of work under contract, if we don't make proper preliminary estimates on contracts how will we take care of our finances? What I mean is this: If you are simply making preliminary estimates of quantities, and your estimates overrun 15 to 20 per cent, there is going to be a day of reckoning. Take $30,000,000 worth of work, if you overrun that by 20 to 25 per cent somebody is going to be up against it good and hard and proper. I want to say to you, when you make your detailed estimates, try to get as near to the point as possible.

I know we double check everything. Some people may think the precautions we take are unnecessary, but there is not a single plan that goes out that is not checked in the central office. Notwithstanding the fact that you may term that unnecessary, we are carrying on the work this year and our cost will be less than 6 per cent. Had we had a fair working season we would have been under the 5 per cent limit in handling all our work.

I think any big business organization that can do business and expend $25,000,000 or $30,000,000 on a 5 per cent basis is to be congratulated. But the point I am trying to drive home is the fact that you can not be too careful in the preparation of plans, in getting out details. I have given considerable thought and study to the matter and do not see where there is any way you can better that. If we could save a nickel on every plan we would like to do it. And we are trying to do it, and at the same time trying to protect the interests of the State.

TRAINING THE ORGANIZATION.

As far as the shortage of engineers is concerned, I want to say to some of these States that are getting ready for large programs, you must train your own organizations. There is no use going out and loading yourself up with a lot of lame ducks. There are plenty of lame ducks floating around. You will get into trouble. Pick your own men, the bright prospects, train them, then you will have something to build on. We follow that policy and absolutely will not fill any of our higher positions from outside the organization. We pick up what we consider the brightest prospects we can find, put them through various lines of work, make them feel they have something to work for. We take the attitude that a man is worth more to us than he is to the other fellow. We have to make him feel he has something to work for, that there is a prospect ahead of him. We must keep him satisfied, and there is only one way, that is to increase his salary as he earns it.

We have a commissioner who believes in paying a man just what he is worth. He is opposed to any fixed salary for any one position. But you must train your organization. We have at the present time 286 inspectors. They are not all good men, by any means. But every man that has made good during the past working season will be carried this winter at his full inspector's salary, no matter whether he is assigned to survey work or field work. We expect to bring into our central office this January those fellows we think are bright prospects and put them through a course of training. In other words, we shall run a regular two weeks' school or college course. We believe that after that two weeks' course (which will cost us in the neighborhood of $15,000 or $18,000) we shall have the nucleus of a real live organization to build on for next year.

The results obtained depend entirely upon the inspection. I don't care how good the engineer or supervisor or executive manager is, if you haven't proper inspection you are going to fail. And you can not go out and find a trained inspector. Why not spend a little money in training your own men?

EXPERIENCE WITH PROJECT ENGINEERS.

Thomas H. MacDonald, Chief of Bureau of Public Roads: It is perhaps not very fortunate, in the interests of harmony, to inject such a topic into this meeting, but it seems to me that we would not be taking the position that we should take if we did not state that up to the present time our experience with so-called project engineers on Federal projects has not been satisfactory. We do not believe that we can obtain the right kind of engineer from without the organization. Naturally, we expect that newly established highway departments and rapidly expanding highway departments will have to take on men and train them as rapidly as possible, and we will assist and sympathize in that development. But I do not believe, and this is personal and final, that we shall be able to obtain satisfactory highway engineers when project engineers are chosen outside the organization itself.

I suppose there are few departments which have made more miles of survey within the last few months than the Iowa department. I will call on Mr. White to tell us something of the methods they are using to get a large mileage of roads under survey.

F. R. White, chief engineer, Iowa: When we started out last spring we had three survey parties. They had a very small program before them. Of course we had to expand to handle the large amount of work that was thrown upon us under the new law, and we wound up the season with 30 parties. We were doing about 225 miles a month.

We may say that we have no complaints to make about the requirements of the Bureau of Public Roads with reference to the details of the survey or the details of the plans. In fact, I think we are putting more detail on the plans than the Bureau of Public Roads calls for, because we believe it is labor well spent.

I can heartily agree with the statement that if we do not get our preliminary plans right we are going to come to grief. We check all our quantities, and double check them, so we know within reasonable limits that they are right.

As to getting your plans in good shape, I wish to mention a little instance on one of our Federal projects that came to my attention this fall. It was one of our early projects, in which there was an offset in the alignment. In the original survey the engineer had been just a little too economical of the right of way. He made too sharp a jog. Mr. Jones, who had charge of our plans, and I were going over them, and the matter was mentioned at that time. We said we will take care of that in the spring. This fall I went over the construction, and found that we had not taken care of it. The jog is there. It is not bad, but it just is not good. We ought to have held up the plans, even though it did mean delay, until we had got that straightened up and had made that original plan what it should be. If we had done that our construction would now be right. With a large mileage of road work going on, as Col. Uhler says, you will have to depend to a large extent on the man on the job; and if you give that man a plan that is not right he is going to give you a road that is not right. And the chief engineer, or supervising engineer, will not come around until something is done that is not right; all he can do is to swear about it.

CARE WITH PRELIMINARY PLANS.

H. K. Bishop, chief engineer, Indiana: I want to stress what Col. Uhler has said about preparation of plans. Two years ago, at Richmond, I was with the Bureau of Public Roads, and I was more or less under fire, with the rest of the officials of the bureau, on account of this same subject.

Some of the States thought we were requiring altogether too much in the plans. I believe there can not be too much care taken with the preliminary plans, and I believe that every dollar you spend in getting the preliminary plans right and in checking quantities is coming back to you two or three fold when you come to construction. When you have to change the plan after the contract is let it costs money. Not only that, but your contractors in bidding on the work soon learn whether or not the plans that you will put out are reliable.

There is another point that was brought out, and that is the fact that our men in charge of the contract work (and especially in the State of Indiana) are more or less inexperienced. We must, as Col. Uhler says, train our organization and must put out plans that those men will take and follow. We have found that where our plans are not properly prepared the men will follow the plans blindly without making the changes more experienced men will make.

I am rather inclined to feel that the Bureau of Public Roads is not making requirements enough. In Indiana, for our own convenience, we are putting on the plans a lot of things that are not required by the Bureau of Public Roads. During this past season we have had to make a great many changes that could have been eliminated by more careful preparation of plans. I went to Indiana in June. We had to hurry in order to get the work under construction this year. We were not as careful as we are going to be next year. We hope to improve, and to go even farther than the bureau requires.

Fortunately we had a good district engineer. I want to say that where we have had to make changes, and we have had to make several of them, we have found our district engineer very reasonable; he will let us go ahead and make changes and submit the changes to him, and he has approved them. We have explained the circumstances to him, telling him we were really up against it, and he has made the changes and has always been agreeable. I think he recognized the changes were good and should be made.

THE COST OF SURVEYS.

Alex. W. Graham, State Highway Engineer, Missouri. In this survey problem you have touched every problem but one. That point is, how much is it right to pay for surveys? Our last legislature gave us the right to make a survey. But our State is young in highway construction, and very young indeed in using engineers on highways construction. We could not quote as high a figure for the surveys as is seemingly necessary, and I would like to know what is proper.

I succeeded in getting our legislature to consent to $100 a mile, and we are getting the bulk of our work done for that price. We have 2,500 miles now under survey and should have the plans ready for rejection or approval in the early spring. We are using the county engineers and we are employing all of the private engineering firms in the State who care to take up the work, and to date I think $135 a mile is the highest we have had to pay.

But engineers in the counties bordering Kansas have tasted blood and are wanting considerably more money. I would like to know what it costs in other States to do this work.

J. Roy Pennell, State Highway Engineer, South Carolina: I think I can answer that question. Put into the cost of the surveys and plans whatever is necessary to properly locate your routes. It is not a matter of cost. That is a secondary consideration. The chiefs of the surveying parties are probably the most important men we have on road work in South Carolina. We are not paying them enough, but we are trying to pay them more than the resident engineers on the work because theirs is the more important work. The cost of surveys in some instances runs as low as $40 a mile. The average has been around $40 to $50 a mile for surveys. Plans cost about $50 a mile, surveys and plans, somewhere between $100 and $110. We supply a chief of party, an instrument man, and a rod man. The counties are furnishing all of the other help.

PERMANENT IMPROVEMENTS ONLY.

State Highway Commissioner Sadler of Pennsylvania has ruled that money derived from the sale of long-term bonds may not be used for the building of short-lived roads. The Pennsylvania law gives the commissioner control over county expenditures for highways. The ruling was brought out by a proposal from Venango County to use the proceeds of a bond issue of $1,000,000 in the construction of cinder roads. In his ruling the commissioner said:

"Our studies clearly demonstrate that a cinder road is not serviceable under modern conditions of transportation. Upkeep of such a road would be continuous and costly. Long-time bonds should not and must not be used to build short-time roads. We can not consent to any improvement paid for with borrowed money—money borrowed for a long period of time—that is not an improvement of a durable type. Any other plan would be extravagant and waste. To put down cinder roads would mean annual rebuilding. The continuing cost prohibits this type of construction; long before the maturity of the bonds issued to pay for the cinders the roads would have disappeared."

MUCH CRUSHED ROCK NEEDED.

It is estimated that the proposed road-building program in Minnesota this year will require about 667,000 tons of crushed rock or gravel, or nearly 20,000 carloads of aggregate. Largely on account of a shortage of crushed stone or gravel 58 miles of road which were to have been built in 1919 were not completed. These roads are to be completed this year, while about 180 miles of new construction requiring crushed rock or gravel has been authorized. This makes a mileage of 250 scheduled for 1920.

ROADS IN A MICHIGAN COUNTY.

According to the annual report of the road commission 258.08 miles of State-reward roads have been completed in Shiawassee County, Mich. During the past year 89.74 miles were built or were under construction, at a cost of $506,975; of which the State will pay one-quarter. At present 191.24 miles of graveled road and 6 miles of dirt road are under maintenance by the county. The average cost of maintenance per year is $128 a mile.

Relations with the Contractor, Influence of Fair Specifications and Inspection.

H. S. Mattimore, Engineer of Tests, State Highway Department of Pennsylvania.

THE subject assigned me by your committee is to my mind very important. There are many serious problems confronting highway officials at the present time. One of the main factors on which the accomplishment of this work depends is the securing of reputable contractors to undertake construction of these highways. It is a pure business proposition with these companies, and there is no reason why they will not seek it providing the highway officials make it attractive. This does not necessarily mean exorbitant prices. Fair prices with fair treatment and intelligent, clear specifications, with competent enforcement, generally proves to be a greater incentive than high prices coupled with extensive delays caused by incompetent inspection, indecision, and indefinite specifications.

Just what do we mean by friendly relations between State and contractor? Theoretically, it is a relation between the engineer and the contractor where both parties have the same views regarding the performance of a contract, and where the work is accomplished with little or no friction during its progress. We will have to admit that such a relationship is a Utopian one. In the first place we have one party interested mainly for financial gain, while the other being the purchaser, or his representative, is naturally interested in seeing that the article paid for is in his judgment equal to that which was agreed to.

Now, do not misunderstand me, I do not assume that as a class contractors, although seeking financial gain, are not willing to live up to their agreement. In fact, I really think otherwise. With very few exceptions our modern contractor is a big business man anxious to do good work and maintain friendly relations and thereby establish a good reputation. On the other hand, our engineers are fair minded, or at least try to be, and their decisions are influenced only from the standpoint of obtaining what in their judgment is a good quality of work.

SOME CAUSES OF CONFLICTS.

The causes of conflicts between the engineers and contractors are many and varied, but broadly they can be summed up as differences in viewpoint. These are bound to exist so long as individuals are of different character and mind, and in fact the stronger the character the more the argument necessary to change the viewpoint. Do not confuse this with ignorant stubbornness. We must be broad enough to realize that there are many problems in highway work that have more than one correct solution.

The highway official has full power to specify the character of work that the contractor must perform, and in justice to the State he must see that this work is performed according to these specifications. Now, to my mind, this is the source of many of the troubles arising during the progress of the work. The contract is taken by the contractor and he agrees to perform the necessary work in accordance with certain specifications. These specifications are written by the engineers and supposedly understood by the contractor. But are they always so understood? Are all specifications clear? As an answer consult articles in current numbers of engineering and contracting journals, also examine court records of State versus contractor on highway cases. In the latter you will find judge, jury, and many legal authorities trying to interpret various clauses in specifications. This in itself should convince us that the specifications must be clear. Make them concise if possible, but do not sacrifice clearness.

POINTS AS TO SPECIFICATIONS.

There is much to be said regarding specifications. In the first place they must not be a product of one mind. A clear and concise specification, if written by an individual, should be so written only after ideas are obtained from men directly connected with the details of construction. Good practice must be adhered to and all methods must be described as definitely as possible.

Do not specify better quality or more detail than you expect to obtain. We have all seen specifications with many paragraphs or phrases which were apparently written to act as a club over the contractor. They were supposedly intended as an insurance against a dishonest contractor. Such insurance leads to high bids, and large, reputable contracting companies will hesitate before bidding under such specifications, and when they do bid it will be high enough to play safe.

Occasionally another type of specification is encountered which is so open and broad that it is dangerous. I refer to specifications which, instead of definitely specifying qualities and describing methods, will call for work being done to the satisfaction of the engineers. This type is a survival of the days when the chief engineer or competent assistants could give much time to details. I doubt if such specifications proved satisfactory even then. At any rate, in the present days they would be hazardous for both State and contractor. No man can satisfactorily handle all details in supervising the large amount of work being done at present, and much supervision has to be left to subordinates. It is a careless and unnecessary procedure to place the responsibility of deciding broad questions on men of limited experience. Furthermore a reader of such specifications is impressed with the idea that the State presenting them was in ignorance of just what they did want.

The main factors affecting the relationship between the contractor and the State therefore might be enumerated as first, the type of specification under which the work is done; next, the interpretation of these specifications and finally their enforcement.

INTERPRETING SPECIFICATIONS.

I have briefly discussed two general types of specification to be avoided, and too much emphasis can not be placed on these points. In order to play fair, the engineers or other officials responsible on the part of the State must see that their specifications are clear, and that methods are definitely stated as far as it is practical to do so. If we expect to avoid friction during the progress of the work, we must have a proper understanding of what is expected, and this information should be conveyed in the specification. We can not expect a better class of materials and workmanship than is available. If we call for them the result will be that if the contract is ever completed we will find that we have not met the specification requirement but will probably be faced with the fact that we paid the price for them. A reputable contractor will take the specifications in good faith and assume they will be enforced. If they are impractical or not properly enforced the State is the loser, as a successful contractor prepares for the worst condition and bids accordingly.

Now, all specifications must be interpreted in many points, and as it is within their authority, this is entirely controlled by the State representatives. The type of man invested with this authority is a large factor in determining the relationship with the contractor, and also has a great influence on future prices. A broad minded man of experience insists upon an excellent quality of work, but he is reasonable enough to insist on this being obtained in the most expensive way.

RESPONSIBILITY OF INSPECTORS.

A certain amount of responsibility and some authority has to be given to the inspector on the contract. The experience of this man and his general character has a great influence on the work and the relationship maintained. This is the State employe who is most intimately associated with the contractor; and his decisions, although in many cases of a minor nature, are bound to have their effect on the subject under discussion. It is true that a good specification leaves little to the decision of the inspector, but we must realize that there are still many points on which he has very little to guide him except past experience and good practice.

The first duty of an inspector is to inspect and insist on quality and compliance with specifications. Any failure on his part, in this regard, is an absolute neglect of duty. It can be said in praise of the engineer or inspector, from a moral standpoint, that a very small proportion deliberately err on the side of neglect of duty so far as their understanding of the specifications are concerned. In fact, their main faults are improper interpretation of the specifications; insufficient detailed knowledge of the different phases of the work, thereby making them uncertain in making decisions; inexperience, thereby unfitting them to determine between a major or minor cause for complaint; and finally a lack of cooperation with the contractor. This latter, and inexperience, are probably the main causes of delays on many contracts. The inspector should always see that the contract is performed in accordance with specifications, but instead of constantly complaining he should suggest methods for rectifying poor conditions. His aim should be to secure results and cooperate with the contractor in getting them. For example, in working local materials the inspector is, or should be, informed as to what is required, and having facilities for determining this he can guide the contractor in working deposits, so as to insure the delivery of acceptable material to the site of the work. Here I wish to emphasize that there is no intention to interfere with the contractors methods of working. The inspector should cooperate to the extent that no large amount of material will have to be rejected after hauling to the roadside. You can readily see how such cooperation on the part of the inspector will reduce costs to the contractor which in the end results in lower bids, and at the same time maintain a high standard of quality in the work.

An inspector should avoid indecision; a firm positive attitude on his part will command respect and maintain friendly relations to a greater extent than will the apparent indecision encountered on many contracts. The complaints from contractors because of indecision on the part of the engineer or inspector far outnumber those in regard to positive directions, even though the latter are at time somewhat severe.

AIDING THE CONTRACTOR.

All highway departments should aim to furnish competent, reliable information when calling for bids. This gives some definite knowledge to the contractor and allows him to bid with intelligence and thereby reduce his so-called contingency or safety item. Under this head might be mentioned sources of approved materials for construction. It is expected that a contractor will inspect the highway before bidding, but having no facilities for determining quality he must figure on sources of known quality regardless of economy. All available material sources should be investigated by the State and full information furnished with the proposal or bidding sheet. This investigation of materials should be made as complete as possible. So far as I know no attempt has ever been made to guarantee these sources in quality and quantity. It is a question for thought whether it may not pay in the end to do so, but regardless of this I know from past experience that furnishing information on material sources, without guarantee, has proved economical. These sources, although not guaranteed, must be reliable, and great care and pains taken in their investigation, or otherwise very little benefit will result.

Highway officials desire to be fair and hope to impress this sense of their fairness on the contractor, not only to attract bidders, but from the general idea of fairness itself. In order to do this we must impress the contractor with the fact that in giving due consideration to the legal side of a contract we also know and consider the moral side.

DISCUSSION OF MR. MATTIMORE'S PAPER.

Paul D. Sargent, chief engineer of Maine: There are one or two points in conncetion with this topic which come to my mind. It seems to me that if contractors are intelligent and fair and honest, and engineers are intelligent and fair, there will not be anything but fair relations between them.

But, as we were told by our friend from Washington this morning, the doctors, lawyers, and bankers want to tell the engineers how to build the roads, and in this line of work, I don't know why it is, practically every man you meet thinks it is the easiest thing in the world to build a road. We have had the experience in our State shared by others, I suppose, of having a lot of inexperienced men bid on highway work, though they had no suspicion of what it meant to build an improved road. We have had men bid on our work, (and we have been forced to let the contract to one such) who could not read or write. Now that is an extreme sample of one class of men we have to deal with. There is not anything you can do to help men of that class that they will say is fair.

I think most engineers are disposed to be fair, and it has never been my observation that the engineer has tried to crowd the contractor if he had a fair man who wanted to do a fair job. Many times we have had contractors who would give us suggestions that would save them money and make the work just exactly as good, and we have always been glad to meet them half way.

I remember an experience I had five or six years ago with one of the best contractors we ever have had on our work. The first time I visited his work I had never seen the superintendent and he never had seen me. I found him reprimanding the foreman who was laying a side drain and covering it with improper material. He made him take the material up and substitute good porous gravel. I immediately said, "I guess this fellow and I can get along all right." He has been doing work six years and we have never had a difference. He always does first class work, simply because he wants to, and he follows his specifications with intelligence. When you have a man like that to deal with it is not necessary to have a lot of hard and fast specifications, but when you have an ignorant fellow, you must draw specifications that he can not depart from.

When the honest fellow reads the specifications, he makes up his mind to bid against the worst contingency that may arise, fearing, of course, a rigid and arbitrary interpretation. I have always felt, when letting a job by contract, that we were paying even the good men for all that very minute detailed description we put into the specifications. They all bid on the worst possible contingency and then get away with a reasonably fair and honest job. Consequently we pay more than we should. But I don't know how to protect ourselves against the unscrupulous fellow unless we do have a rigid specification.

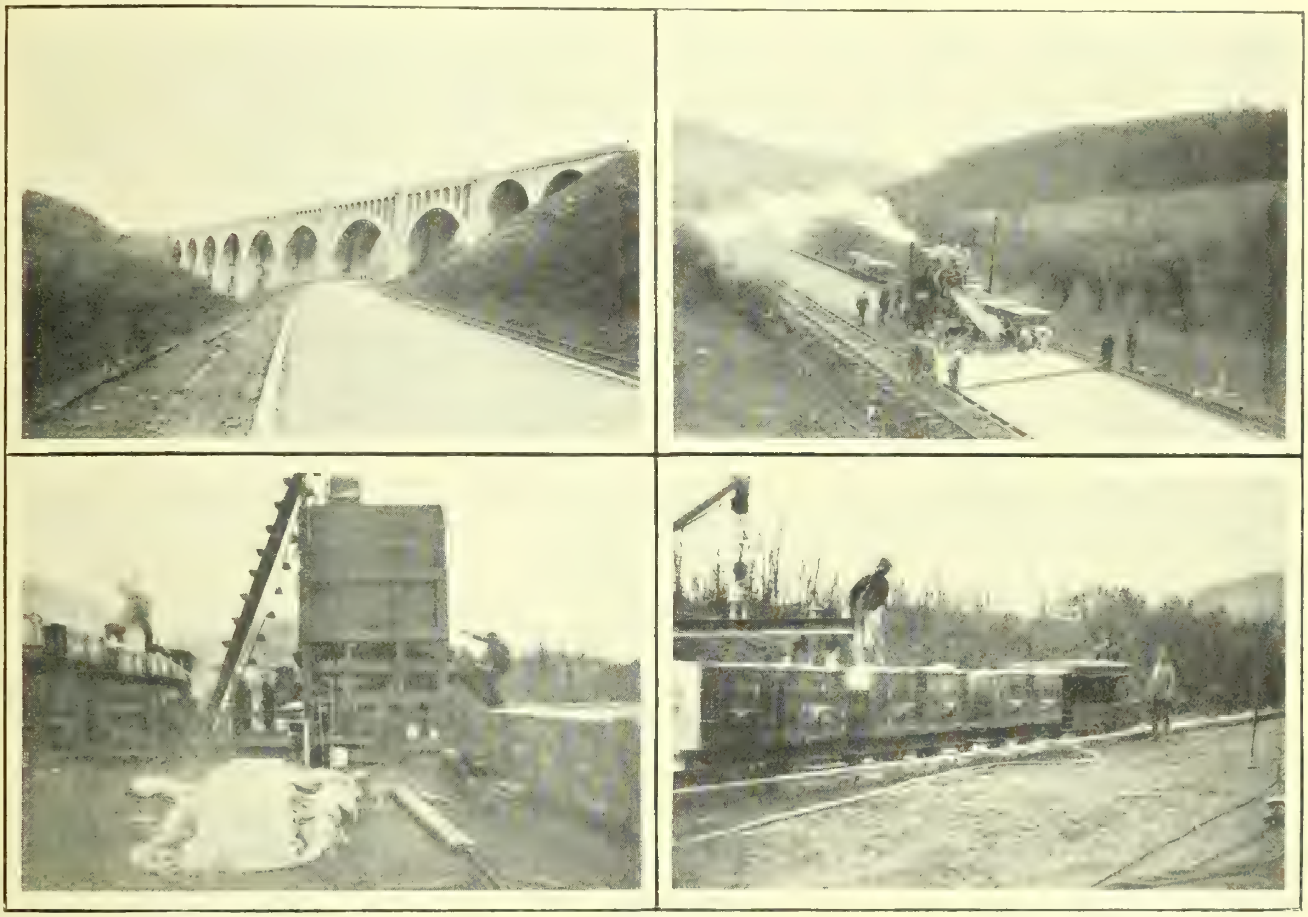
I have had new contractors come to our office to bid on work. They would come around and ask who was going to be the inspector. "Is he around here, can I see him? I would like to talk with him about five minutes, I would just like to get acquainted with the fellow and see what he looks like, and then determine whether I want to bid on the job or not." I have had that happen frequently. The contractor simply wants to see if he is going to have a fair man for an inspector. He wants to know if he is going to have a man to work under that he can get along with in a good and fairly reasonable way. It seems to me very much more depends on securing intelligent contractors and fair engineers than on the technicalities and the details of the specifications.

UTAH ROAD BUILDING.

For the year ending November 30, 1919, the State highway department spent $3,238,566.21 for road construction and maintenance. This is in addition to the funds expended in the State by local authorities on roads which are not a part of the State road system and that spent in the State by the Federal Government on forest roads, either independently or in cooperation with the State and local authorities. The largest monthly disbursements in the history of the State's road work was $586,399.94 in October.

PENNSYLVANIA'S LACKAWANNA TRAIL.

By A. C. Rapelje, Senior Highway Engineer, Bureau of Public Roads.



On the Lackawanna Trail. Above, left, Trail passing under one of the new viaducts of the Lackawanna Railroad; right, Double system of industrial railway used for transporting materials on the State's section. Contractor uses 10 miles of 60-pound, 36-inch gauge, main line track carrying locomotive, and 2,000 feet of 24 gauge light industrial track for locally supplying two mixers. Below, left, Semi portable transfer and batch gauging bin accompanying each mixer outfit, batch gauging box being discharged into cars on industrial track; right, 3-ton Plymouth gas locomotive operating local train of batch cars.

THIS highway project as its name implies runs through the central portion of Lackawanna County, from Scranton, Pa., northerly through Susquehanna County to a connection with the New York State Trunk Line route to Binghamton, N. Y. Just whether the name comes from the county or whether it is a compliment to the laying of the project on the abandoned double track roadbed of the Delaware, Lackawanna & Western Railroad, commonly called the "Lackawanna Railroad," I am unable to state; but in either case or in combination it matters little, for though the Lackawanna Trail in name may have reached back over a period of centuries, its future is of what I have to write. It is quite probable, were we to trace back and go over the years, history would reveal this route originating with the Indians, and with the advance of civilization, the cows, then the bridle path, then the ordinary earth road too tap the rich anthracite mines of Lackawanna County, and lastly, the double-track steam railroad recently abandoned for a more direct route, meaning a saving in distance, time, grades, and alignment. This, however, is not the end. The State highway department, automobile associations, and local interests sensed the desirability of putting this abandoned tract of railroad property to highway use and the Delaware, Lackawanna & Western Railroad philanthropically deeded this right of way for such use without cost to the State. This act on the part of a railroad corporation rather upsets the old-time theory of getting "something for nothing" from a railroad corporation. The project thus unfolds itself into one of unusual interest, based on the possibilities of highway construction on a basic foundation, embodying light curvatures and gradients with ample width without additional cost, on a subgrade prepared and pounded down by heavy rail traffic for years. Here is the ideal in "preparedness," drainage, and all of the minor essentials that go toward making the perfect highway.

The State highway department has planned and is now placing under contract, sections of 18-foot width standard concrete base, 6 inches in thickness with 6-inch curbing; and for the wearing surface a 2-inch bituminous surface, specification A (sheet asphalt pavement) will be used. This work is carefully laid out by transit to fit the roadway width to the best advantage; curves are to be elevated and where necessary widened, as are the easements at points of beginning and ending of the sharper curves, which are infrequent. The work is to embody all of the high-grade standards now used throughout the State, and due to its importance as a connecting route between two large industrial cities and the beauty of its mountain scenery it is assumed that the route will meet with popular favor with summer tourists throughout the United States. The project when completed will be about 36 miles in length.

Two sections are already let to contract, the first being at the Scranton end covering 13.204 miles, for $525,563.47, of which Federal aid has been authorized for $289,059.91. This section of the project is known as Federal aid project No. 66. Of the amount, $83,092.87 of the bid price is for the construction of bridges. At another point somewhat removed from this work, a contract has been let for 10.19 miles at the bid price of $342,637.46. This work was also planned as a Federal aid project, but it was found that the State had taken up about the full Federal aid allotment on the 76 other Federal aid projects now being constructed throughout Pennsylvania, leaving an insufficient amount remaining to be applied to this project. With the 1921 apportionment of Federal aid, the projects yet to be let on the Lackawanna Trail will doubtless be under Federal aid.

With the completion of this road and its opening to traffic it is expected that the automobilists, if not generally in a few instances, will realize they have a very tempting stretch of highway and distance to negotiate with, the long tangent and easy curvatures with grades of no resistance, and this will cause those of a certain turn of mind to "step on her" and step hard.

FEDERAL-AID PROJECT APPROVALS AND AGREEMENTS NOVEMBER, 1919.

Project.			Length in miles.	Material.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
State.	No.	County.						
Alabama	14	Talladega		Chert and gravel		Nov. 4	[1] $18,590.00	[1] $9,295.09
	71	Dallas	4.166	Gravel	Nov. 18		16,217.68	8,108.84
Arizona	18	Pina and Cochise	28.00	Sand-clay and gravel	Nov. 8		283,469.00	119,234.50
Arkansas	24	Ashley, Desha, Drew, Chicot, and Lincoln.	152.99	Asphalt and macadam		Nov. 18	2,684,177.10	332,000.00
	27	Columbia	14.03	Macadam		do	53,807.60	23,046.05
	28	St. Francis	18.58	Gravel		Nov. 3	238,262.72	50,000.00
	38	Howard and Sevier	9.84	do	Nov. 8		55,461.28	24,000.00
	46	Grant	12.48	do	Nov. 3		24,110.90	12,000.00
	58	Hempstead	5.02	do	Nov. 28		34,897.98	12,500.00
California	24	Orange	9.37	Bituminous		Nov. 19	139,889.31	69,944.65
	25	Santa Barbara	3.56	Concrete		Nov. 18	85,373.97	42,686.98
	26	Kern	10.73	do		do	329,598.61	164,799.30
	32	Siskiyou	17.64	do	Nov. 8		390,775.00	195,387.50
	33	San Bernardino and Riverside	7.10	Earth	Nov. 5		108,438.00	54,219.00
	34	San Diego	6.61	do	do		79,876.50	39,938.25
	35	do	13.80	do	do		226,105.00	113,052.50
	36	Humboldt	7.34	Concrete	Nov. 24		131,587.50	65,793.75
	37	Fresno	11.99	do	Nov. 19		306,061.25	153,030.62
	38	Mariposa	7.84	Earth	Nov. 24		171,600.00	85,800.00
Colorado	4	Garfield and Rio Blanco		Gravel or stone and graded earth		Nov. 26	[1] 22,494.89	[1] 11,247.45
	18	Pueblo				Nov. 3	[1] 12,318.79	[1] 6,159.40
	24	Castilla	5.844	Earth and gravel		do	20,044.39	10,022.19
	28	Summit	2.03	Earth	Nov. 18		34,376.59	17,188.29
	50	Elbert	16.88	do	do		48,446.75	24,223.37
	57	Prowers	1.409	Concrete		Nov. 3	39,725.95	19,862.97
	65	Ouray	1.155	Earth	Nov. 4		68,432.59	24,750.00
	77	Mesa	2.477	Concrete	Nov. 19		99,798.60	49,540.00
	78	Eagle	2.759	Earth	Nov. 3		114,503.27	55,180.00
Georgia	25	Candler	14.66	Sand-clay		Nov. 18	46,486.16	23,243.08
	26	Bullock		6 bridges		Nov. 24	57,157.06	28,578.53
	30	Cobb	16.815	Topsoil		Nov. 3	75,120.91	37,560.45
	59	Jackson	4.259	Sand-clay		do	38,477.27	19,238.63
	75	Gilmer	.56	Concrete	Nov. 15		20,652.50	10,326.25
	104	Jasper		Bridge	do		9,295.90	4,647.95
	105	Coweta	4.88	Sand-clay	Nov. 29		40,603.75	20,301.87
	106	Sumter	3.00	Bituminous	Nov. 26		58,759.58	20,015.92
	107	Worth	3.98	do	Nov. 26		118,702.92	50,000.00
	108	Merriwether	12.00	Sand-clay	Nov. 24		70,240.06	30,000.00
	111	Union	6.50	Gravel or macadam	do		53,154.75	26,577.37
	112	Laurens		4 bridges	do		66,435.60	27,194.90
	113	Pulaski		3 bridges	Nov. 29		84,270.96	30,000.00
	114	Ware	7.00	Bituminous, brick or concrete	do		240,625.00	50,000.00
	115	Chattooga		Bridge	do		17,379.30	5,000.00
Idaho	23	Twin Falls	27.00	Bituminous	Nov. 5		664,290.00	332,145.00
	24	do	8.82	Bituminous or concrete	Nov. 6		279,621.76	139,810.88
	29	Kootenai	12.50	Gravel	Nov. 24		197,990.76	98,995.38

[1] Modified agreements. Amounts given are increases over those in the original agreements.

Project.			Length in miles.	Material.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
State.	No.	County.						
Illinois	[1] 1	DuPage, DeKalb, Kane, Ogle, Lee, Whiteside.	13.311	Concrete and bituminous macadam resurfacing.		Nov. 19	$418,400.63	$209,200.31
	[2] 1	do		do		do	[2] 10,742.97	[2] 5,376.48
	[3] 6	Sangamon, Menard, Mason, Tazewell, Peoria.	4.37	Concrete		Nov. 3	181,812.98	90,906.49
	[3] 6	do	10.503	do		Nov. 19	386,498.92	193,249.45
	[3] 6	do	38.855	do		do	1,460,126.23	724,034.12
	[4] 9		29.151	Brick or concrete		do	1,008,292.87	504,146.41
Indiana	9A	Bartholomew and Johnson	8.452	Asphalt, brick, or concrete		Nov. 24	317,237.19	158,618.59
	12B	Jackson	6.135	Concrete, brick, or bituminous		Nov. 18	231,415.36	115,707.68
	14	Vigo	4.661	Asphalt, brick, or concrete		Nov. 24	162,698.91	81,349.45
	17A	Lake, Porter, and Laporte	11.382	Asphalt, brick, or concrete		Nov. 24	410,472.01	205,236.00
	18AB	Tipton and Howard	9.981	Brick, concrete, or bituminous		do	375,387.77	187,693.88
Iowa	14	Harrison	15.60	Earth		Nov. 3	94,487.14	47,200.00
	17	Dubuque	21.89	do	Nov. 1		142,428.00	71,200.00
	48	Humboldt	1.87	Concrete or brick and gravel	Nov. 24		78,324.12	37,400.00
	61	Cerro Gordo	6.05	Brick or concrete		Nov. 24	241,706.08	120,000.00
	67	Hamilton	20.90	Earth	Nov. 24		70,455.00	35,200.00
	69	Monona	39.40	do			168,861.00	84,400.00
	71	Washington	22.00	do	Nov. 19		154,550.00	77,200.00
	75	Marion	23.20	do	do		123,921.60	61,900.00
	76	Chickasaw	13.50	Gravel	Nov. 4		86,847.75	43,400.00
	85	Butler	15.62	Earth	Nov. 29		162,410.38	81,300.00
	88	Bremer	16.40	do	Nov. 6		51,636.20	25,800.00
	91	Wayne	17.80	do	Nov. 26		110,836.00	55,400.00
Kansas	27	Reno	35.00	Brick or concrete	Nov. 18		1,563,661.55	525,000.00
	28	Ford	−16.60	do	do		920,856.20	[5] −249,000.00
Kentucky	19	Mercer	7.50	Macadam	Nov. 29		74,993.60	37,496.80
Louisiana	16	East Baton Rouge		Gravel		Nov. 19	[6] 23,062.44	[6] 7,043.05
	46	Red River	8.05	do	Nov. 3		77,048.01	38,524.00
	52	Rapides	13.30	Sand-clay and gravel	Nov. 19		163,803.58	81,901.79
	57	Grant and LaSalle		Bridge	do		16,991.15	8,495.52
Maine	5	Washington	5,184	Gravel	Nov. 6		89,617.00	44,808.50
Maryland	9A	Frederick	2.00	Concrete		Nov. 26	60,700.53	30,350.25
	12B	Carroll	2.60	do		do	63,526.65	31,763.32
	16A	Howard	[6] 1.18	do		Nov. 25	[6] 57,664.75	[6] 24,880.53
Massachusetts	7	Hampshire	4.659	Macadam		Nov. 19	173,633.07	86,816.53
Michigan	41	Oakland	10.058	Bituminous	Nov. 19		556,847.59	201,160.00
Minnesota	48	Swift	19.575	Pavement and gravel		Nov. 5	266,499.67	120,000.00
	64	Rice	12.90	Asphalt, brick, or concrete		Nov. 19	420,563.51	150,000.00
	66	Big Stone	10.42	Gravel		Nov. 24	82,472.80	40 000.00
	68	Rice	4.61	do		do	27,320.28	13,000.00
	71	Martin	5.02	do		do	55,237.89	25,000.00
	72	do	4.54	do		Nov. 19	51,394.75	25,000.00
	74	Sibley	21.74	do	Nov. 19		189,992.00	94,996.00
	77	Rice	5.51	do		Nov. 24	46,212.48	23,000.00
	81	Marshall	26.67	do		do	139,333.59	55,000.00
	91	Kanebec	16.50	do	Nov. 5		148,225.00	74,112.50
	92	Anoka	26.35	Concrete and gravel	Nov. 19		310,750.00	155,375.00
	99	Todd	17.38	Gravel	Nov. 24		112,985.40	56,492.70
Mississippi	24	Marshall		Slag or gravel		Nov. 10	[6] 15,546.25	[6] 17,435.62
	30	Lauderdale		Gravel		Nov. 3	[6] 13,964 16	[6] 7,111.67
	41	Wilkinson	17.90	do	Nov. 19		142,758.00	71,379.00
	46	Montgomery	4.18	do	Nov. 18		78,287.00	39,143.50
	47	Holmes	3.71	do	Nov. 19		22,844.25	11,422.12
	65	Yazoo	6.80	do		Nov. 3	49,142.50	24,571.25
	86	Lincoln	3.61	do	Nov. 18		55,815.65	27,907.82
Missouri	23	Pettis	5.31	Bituminous		Nov. 26	60,759.66	30,379.83
	28	St. Charles	1.66	do		do	22,714.07	11,357.03
	38	Lewis	8.50	Gravel	Nov. 18		88,977.37	44,488.68
	43	Montgomery	8.241	Macadam	do		62,043.41	31,021.70
	44	Randolph	8.50	Earth	Nov. 24		49,555.00	24,777.50
	45	Hickory	7.50	Gravel	do		26,837.80	13,418.90
	46	do	4.50	do	Nov. 25		15,548.28	7,774.14
	47	Cedar	9.73	do	Nov. 24		43,666.02	21,833.01
Montana	4	Carbon	3.43	do		Nov. 18	33,243.05	16,621.52
	26	Fergus	1.13	Earth		Nov. 19	21,976.98	10,988.99
	54	Cascade	.86	Gravel	Nov. 19		5,868.50	2,934.25
	62	Toolo	29.00	do	Nov. 29		134,816.00	67,408.00
Nebraska	38	Frontier		Earth		Nov. 3	[6] 2,071.52	[6] 1,039.76
	70	Stanton, Cumming, and Wayne	39.20	do	Nov. 19		126,324.00	63,162.00
	75	Fillmore and Thayer	17.87	do		Nov. 26	70,000 19	35,000.00
	90	Merrick	22.20	do	Nov. 24		55,825.00	27,912.59
	102	Dawes and Sioux	31.70	Sand-clay	Nov. 19		132,550.00	66,275.00
	105	Dawson	13.45	Gravel		Nov. 19	57,096.60	28,548.30
	106	Gage	1.15	Brick or concrete		Nov. 26	59,691.04	23,000.00
	110	Knox and Boyd	40.10	Sand-clay	Nov. 18		130,928.60	65,464.30
	112	Douglas	16.80	Earth	Nov. 24		70,950.00	35,475.00
	113	Knox	16.70	do	do		62,260.00	31,130.00
	114	Dundy and Hitchcock	20.80	Sand-clay	Nov. 5		85,558.00	42,778.00
	116	Johnson	21.00	Earth	Nov. 19		76,670.00	38,335.00
	117	Garden	13.10	do	do		40,777.00	20,388.50
	123	Richardson	1.36	do	Nov. 24		5,445.00	2,722.50
	125	Brown	29.50	Sand-clay and earth	do		64,699.80	32,349.90
	133	Otoe and Lincoln	54.90	Earth	do		176,253.00	88,126.50
Nevada	11	Esmeralda		do		Nov. 26	[6] 5,914.63	[6] 2,957.32
New Hampshire	22	Grafton and Merrimack	1.00	Gravel		Nov. 24	10,071.27	5,035.63
	29	Merrimack	.538	do		do	5,989.83	2,994.91
	36	Cheshire	1.13	do		do	12,065.95	6,032.97
	40	Merrimack	.909	do		Nov. 24	10,004.91	5,002.47
	54	Strafford	2.04	do		do	21,135.07	10,567.53
	65	Hillsborough		do		Nov. 3	[6] 1,643.10	[6] 2,321.55
	68	do	.833	do		Nov. 24	15,043.60	7,521.80
	70	Coos	.568	Macadam		do	12,343.87	6,171.93
	71	Strafford	1.08	Gravel		do	16,542.94	8,271.47
	79	Rockingham	1.136	do		do	8,299.06	4,149.53
	88	Hillsborough	2.00	do	Nov. 15		25,036.00	12,518.00

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[1] Includes sections 10, 11, and 16 of project.

[2] Modification of agreement, for section 12 of the project. Amounts given are increases over those of the original agreement.

[3] Separate agreements for portion of project. The first includes sections C–15d and F–15d, the second sections A, G, M, and O–15d, and the third sections, A, B, C, D, E, F, H, J, and L–15d.

[4] Includes sections C, D, E, G–15d, H–15d, K. Q. X.

[5] Statement previously approved withdrawn.

[6] Modified agreements. Amounts given are increases over those in original agreements.

State.	Project. No.	Project. County.	Length in miles.	Material.	Project statement approved.	Project agreement signed.	Estimated cost.	Federal aid.
New Jersey	10	Hunterdon	2.03	Concrete		Nov. 19	$138,472.42	$50,047.07
	12	Atlantic	9.87	do		Nov. 3	346,843.22	173,421.61
New Mexico	37	Union	11.00	Gravel	Nov. 3		93,269.00	46,634.50
North Carolina	9	Polk	12.52	do		Nov. 24	42,617.74	21,308.87
	44	Granville	4.57	Sand-clay		do	45,513.63	15,500.00
	45	Buncombe	7.80	Macadam		do	185,345.25	92,672.62
	68	Harnett and Simpson	28.00	Sand-clay or gravel	Nov. 24		173,077.96	86,538.98
	75	Columbus	7.06	Sand-clay	Nov. 3		24,631.20	12,315.60
	87	Hyde	4.00	Gravel	Nov. 19		56,716.00	28,358.00
	88	do	17.50	Sand-clay	Nov. 25		242,660.00	121,330.00
	97	Macon	8.50	Sand-clay or gravel	Nov. 12		74,806.82	37,403.41
North Dakota	14	Stark		Earth		Nov. 19	[1] 3,565.50	[1] 1,782.75
	15	Sargent		do		do	[1] 51,744.59	[1] 25,872.79
	19	Ramsey		Graded earth		do	[1] 23,178.79	[1] 11,589.39
	33	McIntosh	[2] 3.00	Earth	Nov. 24		[2] 29,520.00	[2] 14,760.00
	42	Pembina	6.00	do	Nov. 6		23,000.00	11,500.00
	46	Traill	4.02	do		Nov. 12	11,847.42	5,923.71
	61	do	12.50	do	Nov. 24		38,500.00	19,250.00
	69	Richland	18.50	do	Nov. 19		54,000.00	27,000.00
	71	do	13.00	do	Nov. 8		36,330.00	18,165.00
	73	Williams	18.50	do	Nov. 19		56,980.00	28,490.00
	74	Mountrail	8.00	do	do		22,880.00	11,440.00
	76	Burke	20.00	do	Nov. 25		52,800.00	26,400.00
	77	do	18.00	do	do		49,500.00	24,750.00
	78	Divide	10.00	do	Nov. 19		27,500.00	13,750.00
	79	do	10.00	do	Nov. 24		40,040.00	20,020.00
	80	Williams	19.00	do	Nov. 19		60,610.00	30,305.00
	81	Ward	13.00	Gravel	Nov. 25		63,206.00	31,603.00
	82	do	15.00	do	Nov. 19		70,950.00	35,475.00
	84	do	25.00	do	Nov. 24		130,130.00	65,065.00
	87	Bottineau	15.00	Earth	Nov. 19		52,800.00	26,400.00
	88	Wells	11.00	do	Nov. 26		39,600.00	19,800.00
	89	Sargent	11.50	do	Nov. 25		43,700.00	21,850.00
	90	Wells	10.00	do	Nov. 26		33,000.00	16,500.00
Ohio	57	Shelby	3.065	Concrete		Nov. 8	100,000.00	35,000.00
	58	do	3.521	do		do	100,000.00	35,000.00
	68R	Perry	3.068	Bituminous or concrete		Nov. 19	81,600.00	40,800.00
	70	Allen	4.43	Bituminous	Nov. 25		123,000.00	43,600.00
	89	Madison	2.42	do	do		73,300.00	24,200.00
	94	Lawrence	4.386	do		Nov. 24	94,000.00	47,000.00
	104	Vinton	4.583	Earth	Nov. 5		46,000.00	18,000.00
Oregon	26	Klamath	8.92	Macadam	Nov. 3		160,806.80	84,403.40
	30	do	13.90	do	do		108,341.75	54,170.87
	31	do	14.70	do	do		173,860.50	86,930.25
	32	Lake	11.00	Gravel	do		125,829.00	62,914.50
	34	Klamath	13.15	Macadam	do		146,234.00	73,117.00
Pennsylvania	86	Erie	3.617	Cement concrete or bituminous concrete on concrete base.		Nov. 26	264,532.21	107,459.78
	56	Center	2.23	Bituminous or concrete		Nov. 19	133,975.11	46,600.00
	66	Lackawanna and Wyoming	13.204	do		do	578,119.81	289,059.90
South Carolina	41	Hampton	15.625	Sand-clay	Nov. 19		148,859.02	74,429.51
	46	Kershaw	2.129	Gravel	Nov. 24		23,614.45	10,000.00
South Dakota	15	Lawrence	22.94	Earth and gravel		Nov. 19	183,166.56	91,583.28
Texas	52	Callahan	34.85	Gravel		Nov. 18	232,152.87	75,000.00
	94	Baylor	4.313	Sand-clay		Nov. 19	24,641.04	10,692.22
	107	Runnels		Bridge	Nov. 19		61,423.36	24,482.50
	111	Scurry	21.521	Gravel	do		92,301.00	46,150.50
	112	Bexar	7.27	Bituminous	Nov. 28		76,057.22	35,802.33
	115	Smith	8.72	Concrete or gravel	Nov. 19		174,481.49	87,240.74
	116	Tom Green	26.542	Macadam	Nov. 28		340,952.16	100,000.00
	117	Denton	10.055	Gravel	Nov. 25		164,896.71	41,224.18
	118	Webb	17.55	do	Nov. 19		116,028.50	41,567.12
Utah	12	Iron and Washington	56.00	Concrete	Nov. 3		1,274,911.56	637,455.88
	15	Iron	47.00	do	Nov. 3		829,237.20	414,618.60
Vermont	1	Chittenden		Gravel		Nov. 18	[1] 4,506.08	[1] 2,253.05
Virginia	37	Bedford and Campbell	6.61	Bituminous		Nov. 5	139,786.68	69,893.34
	54	Rockbridge	2.05	Macadam	Nov. 19		41,085.00	20,542.50
	58	Prince George	11.26	Gravel		Nov. 19	70,952.03	35,476.01
	59	Nansemond	5.40	Concrete	Nov. 18		155,485.00	77,742.50
	62	Roanoke	.72	do		Nov. 5	24,904.00	12,452.00
Washington	46	Garfield	10.81	Macadam	Nov. 19		211,085.66	105,542.83
	47	Columbia	6.57	do	do		112,647.15	56,323.52
	48	Ferry	1.19	Earth	do		26,460.61	6,622.00
West Virginia	47	Wetzel	4.88	Concrete		Nov. 18	106,820.00	53,410.00
	49	Marion	1.42	Brick		Nov. 22	50,850.00	25,165.00
Wisconsin	2	Manitowoc	[2] .59	Concrete or brick	Nov. 19		[2] 21,380.48	7,126.83
	14	Menominee	[3] −4.95	Gravel		Nov. 20	[3] −15,043.53	[3] −5,014.51
	39	Racine		Concrete		Nov. 18	[3] 7,509.71	[1] 2,503.24
	51	Columbia	4.934	Gravel or macadam		Nov. 19	74,964.51	24,988.17
	62	Washington		Concrete		Nov. 24	[1] 11,988.32	[3] 3,996.11
	67	Monroe	2.82	Earth		do	30,446.68	10,148.89
	97	Sauk	[2] 4.30	Gravel	Nov. 1		[2] 30,708.00	[2] 10,236.00
	99	Douglas and Washburn	7.04	do		Nov. 18	62,954.43	20,984.81
	101	Barron	4.253	Earth		Nov. 26	44,793.77	14,931.26
	102	Waukesha	2.31	Concrete		Nov. 19	60,123.69	20,041.23
Wyoming	5	Sweetwater	14.04	Earth		do	28,249.18	14,124.59
	37A	Goshen	9.195	Gravel		do	68,195.60	34,097.80
	38	Hot Springs	3.381	do		do	34,081.36	17,040.68
	44	Carbon	12.217	Earth	Nov. 19		36,300.00	18,150.00
	53	Hot Springs	.627	Gravel or macadam	Nov. 25		24,805.00	12,402.50
	54	Big Horn	6.922	Gravel	do		57,139.50	28,569.75
Total	225		2,427.771				31,774,219.65	14,447,863.46

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[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Revised statement. Amounts given are increases over those in the original statement.
[3] Agreement previously signed canceled.

ROAD PUBLICATIONS OF BUREAU OF PUBLIC ROADS.

***Applicants** are urgently requested to ask only for those publications in which they are particularly interested. The Department can not undertake to supply complete sets, nor to send free more than one copy of any publication to any one person. The editions of some of the publications are necessarily limited, and when the Department's free supply is exhausted and no funds are available for procuring additional copies, applicants are referred to the Superintendent of Documents, Government Printing Office, this city, who has them for sale at a nominal price, under the law of January 12, 1895. Those publications in this list, the Department supply of which is exhausted, can only be secured by purchase from the Superintendent of Documents, who is not authorized to furnish publications free.*

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*Report of the Director of the Office of Public Roads for 1916. 5c.
*Report of the Director of the Office of Public Roads for 1917. 5c.
Report of the Director of the Bureau of Public Roads for 1918.
Report of the Chief of the Bureau of Public Roads for 1919.

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220. Road Models.
230. Oil Mixed Portland Cement Concrete.
249. Portland Cement Concrete Pavements for Country Roads.
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583. Reports on Experimental Convict Road Camp, Fulton County, Ga.
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Public Roads, Vol. I, No. 11. Tests of Road-Building Rock in 1918.

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65. Rules and Regulations of the Secretary of Agriculture for Carrying out the Federal Aid Road Act.
72. Width of Wagon Tires Recommended for Loads of Varying Magnitude on Earth and Gravel Roads.
73. Automobile Registrations, Licenses, and Revenues in the United States, 1916.
74. State Highway Mileage and Expenditures for the Calendar Year 1916.
77. Experimental Roads in the Vicinity of Washington, D. C.
Public Roads Vol. I, No. 1. Automobile Registrations, Licenses, and Revenues in the United States, 1917.
Vol. I, No. 3. State Highway Mileage and Expenditures in the United States, 1917.
Vol. I, No. 11. Automobile Registrations, Licenses, and Revenues in the United States, 1918.
Vol. II, No. 15. State Highway Mileage and Expenditures in the United States, 1918.

FARMERS' BULLETINS.

F. B. 338. Macadam Roads
505. Benefits of Improved Roads.
597. The Road Drag.

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727. Design of Public Roads.
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REPRINTS FROM THE JOURNAL OF AGRICULTURAL RESEARCH.

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Vol. 5, No. 19, D–3. Relation Between Properties of Hardness and Toughness of Road-Building Rock.
Vol. 5, No. 20, D–4. Apparatus for Measuring the Wear of Concrete Roads.
Vol. 5, No. 24, D–6. A New Penetration Needle for Use in Testing Bituminous Materials.
Vol. 6, No. 6, D–8. Tests of Three Large-Sized Reinforced-Concrete Slabs under Concentrated Loading.
Vol. 10, No. 5, D–12. Influence of Grading on the Value of Fine Aggregate Used in Portland Cement Concrete Road Construction.
Vol. 10, No. 7, D–13. Toughness of Bituminous Aggregates.
Vol. 11, No. 10, D–15. Tests of a Large-Sized Reinforced-Concrete Slab Subjected to Eccentric Concentrated Loads.
Vol. 17, No. 4, D–16. Ultra-Microscopic Examination of Disperse Colloids Present in Bituminous Road Materials.

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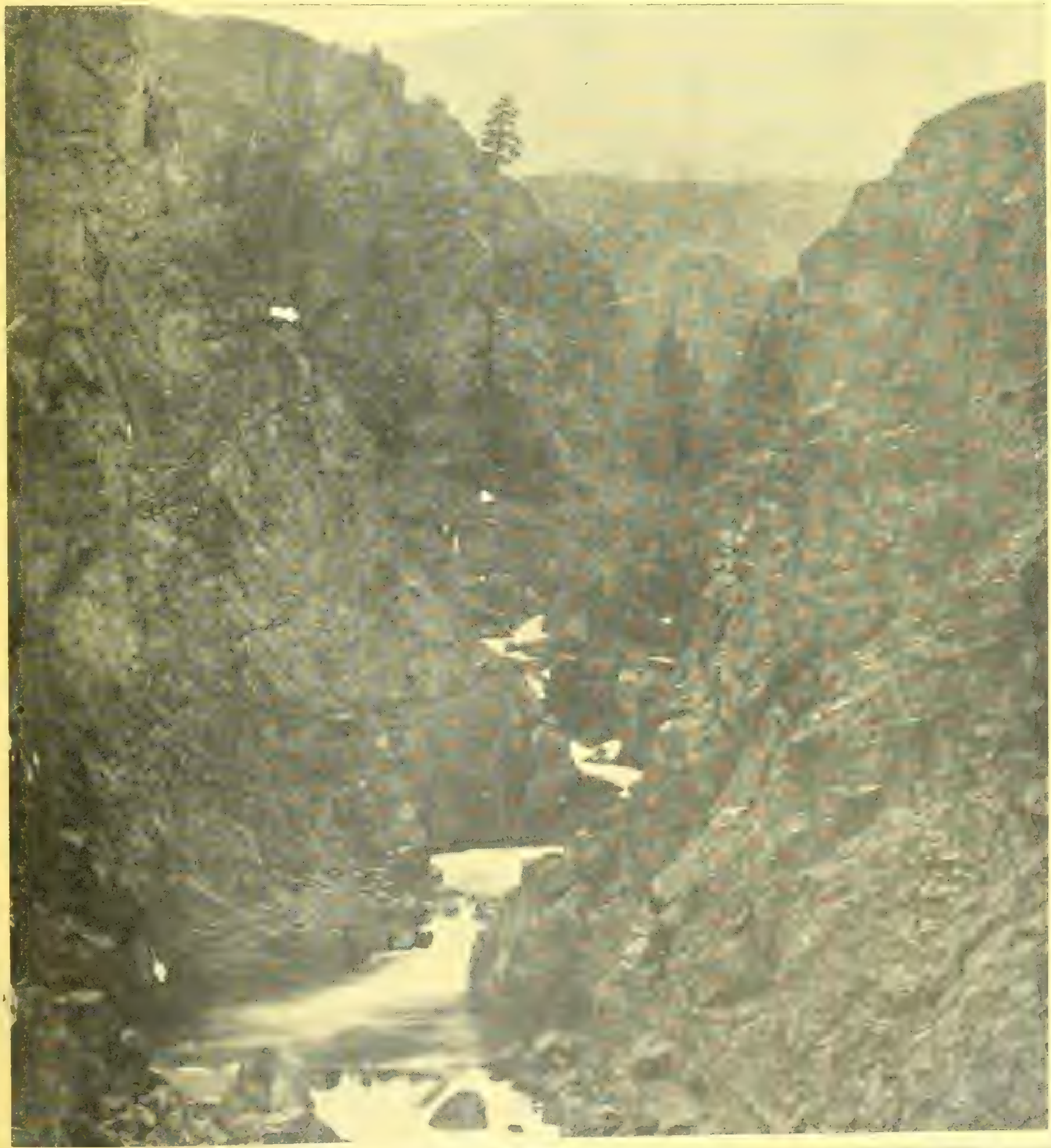
U.S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NOS. 21-22 WASHINGTON, D. C. JANUARY-FEBRUARY, 1920



LOOKING UP CHELAN RIVER ON WASHINGTON FEDERAL AID PROJECT NO. 45

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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U. S. DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

PUBLIC ROADS

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THOMAS H. MacDONALD . . . . Chief of Bureau
P. ST. J. WILSON . . . . Chief Engineer

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RELATIONS OF THE STATES WITH THE BUREAU OF PUBLIC ROADS.

G. P. COLEMAN, Highway Commissioner of Virginia.

WHEN I was asked by your program committee to take this subject I thought it would be advisable to send out a general letter to the various States, requesting them to give certain specific information, and with that in mind, I propounded the following questions:

First. The projects which have been turned down by the Bureau of Public Roads, and their reasons for so doing, with suggestions for meeting these objections and a summary statement including the projects which have been approved.

Second. The objections, if any, which the States have to the law itself, and the rules and regulations of the Department of Agriculture, with suggestions for the improvement of the same.

I have received replies from 28 of the States. These replies have covered such a broad field that I am afraid in dealing with them this paper will infringe on the fields of some of the others.

One thing that has been brought out very positively and clearly, is that the cooperation between the various State departments and the Bureau of Public Roads has improved tremendously in the past 12 months. Mr. MacDonald and his bureau would, I am sure, feel very much flattered and encouraged from the reading of the letters which have been sent in. From these letters I gather the following facts:

CONCLUSIONS FROM REPLIES.

First. That ninety-odd per cent of the projects which have been submitted to the bureau have finally been accepted, and that in the few instances where projects have not been accepted the bureau has been well within the law and that the States themselves have been satisfied that the decisions were correct. The last amendment to the act cleared up the major difficulties in so far as the post-road feature is concerned, as I have received just one suggestion which merely elaborates on the present law, and which will be covered by question No. 2.

Second. Replies to the second question "Objections to the law itself and the rules and regulations of the Department of Agriculture, with suggestions for the improvement of the same," indicate that, on the whole, the law itself is generally satisfactory. However, there are suggested changes from quite a number of the States which should receive our careful consideration: First, that in some of the States, where the development has not been general and where the Government itself is a large holder of the property, some amendment should be prepared which would give to the Department of Agriculture, on the request of the State, certain latitude in the expenditure of the State's allotment in excess of the 50 per cent now allowed by the Federal law. If you will make a study of this situation I am sure that you will agree with me that we should make some effort to meet this situation, for some of the States, particularly those just east of the Rockies in the Middle West, will find it difficult, if not impossible, to meet the Federal aid.

G. P. COLEMAN.

It would be advisable for the bureau to establish a different set of standards of construction for both highways and bridge structures for the different sections of the country. The necessity for this is particularly apparent in these sparsely settled communities. It will be readily seen that what would be characterized "as substantial in character" in Nevada would not meet traffic requirements of Massachusetts or New York. It has also been suggested that on particularly long projects some arrangement should be made for the acceptance of these projects in sections. I think, as a matter of fact, that this is largely covered by the contracts as drawn by the States and can be made without change of the rules and regulations or reference to the Bureau of Public Roads. The Government should participate in the making of surveys, plans, and estimates. This question has been up before the association at various times and there has been a wide difference of opinion, but we have generally agreed that it was not of sufficient importance to ask for an amendment to the law.

It is the general opinion of all of the States that the Bureau of Public Roads has been slow in its acceptance of projects and in paying on the projects.

DELAY IN PROJECT APPROVALS.

Delay in approval of projects seems largely due to incomplete understanding by the bureau of the conditions which obtain and to the State department's failure to prepare the plans and estimates as required by the bureau. This situation can, I believe, be very readily cleared if the bureau will place a resident engineer in each State with instructions to go over the proposed project when the surveys are being made and plans prepared, and the project can then be accepted or rejected on the submission of the plans and estimates, the bureau acting on the recommendations of its engineers. Then any small technical details or defects in the plans and estimates could be cleared up after such acceptance and as the work progresses. This would obviate the delays caused by revisions and the necessary resubmission of plans.

The letters clearly set forth the desirability of such a course on the part of the bureau; that is, placing an engineer in each State, an engineer of sufficient ability to be vested with very broad authority. The State departments are also of the opinion that work would be greatly facilitated if the district engineer was given full authority to pass on all questions other than those of policy. This would undoubtedly lead to a better understanding between the departments and the bureau. It has also been brought out that should this be done it will undoubtedly lead to a better working understanding and the establishment of that confidence between the departments and the bureau which should always exist to accomplish the best results. It is very generally conceded that all of us are anxious and desirous of constructing roads of such type and character as will carry the traffic of the various sections. The signing of the contracts, or agreements, by the highway departments and the Department of Agriculture should be a sufficient evidence of this fact, and therefore the departments, acting with the resident engineer, should be allowed to make such minor changes as the work progresses as may be deemed necessary, without reference to the bureau or being required to resubmit project statements, provided that the costs are kept within the amount of estimates agreed on. To illustrate; it is sometimes advisable to increase the size of a waterway, or do away with others, or change their location. It is also a very common occurrence that a slight change in grade or alignment will improve the general character of the work very materially. All of us can bring to mind many instances where changes could be made to improve our work, but on account of incidental delays they are not undertaken.

THE PAYMENT OF VOUCHERS.

Relative to the delay in payment of vouchers which has evidently caused a great deal of concern and some inconvenience to a number of States, I think, judging from my own experience, that this will be largely cleared up as the departments themselves become familiar with the necessary red tape, or routine. I would suggest that the bureau should establish a definite time for vouchers to be received and payments to be made each month, and that vouchers received after that date would automatically pass for payment to the following month. This would then place the burden on the district engineers and the departments.

It is the consensus of opinion that the bureau has been and is unnecessarily technical in the requirements of details for bridges. It is also the general opinion that some arrangement should be entered into whereby the departments would be allowed to begin work before projects are finally accepted by the United States Department of Agriculture. A great deal of delay and unnecessary expense has been caused by the present arrangement. It therefore occurs to me that this condition could be very readily met by the bureau, should it require, first, that the department would take the responsibility for the cost of the work should the bureau finally not approve it, but that the Government would participate to the full 50 per cent should the project be accepted; second, that the bureau should be notified before work was started on the project in order that it might make such inspections as it deems proper.

The bureau could, with very great advantage, revise its rules and regulations and eliminate repetitions and ambiguities. The adoption of these suggestions will do much to bring about a thorough understanding and to advance the big road interest of the country.

The foregoing is largely taken from the representations of the other States. My experience has been most satisfactory. It is barely possible that, as Virginia is a nearby State, the bureau has been trying out the experiment of placing an engineer in the State to work with the department, and it has worked well and has certainly facilitated our work.

DISCUSSION OF MR. COLEMAN'S PAPER.

By **E. W. JAMES** Assistant Chief Engineer, Bureau of Public Roads.

It can not but be gratifying to one who has been closely associated, both in technical and executive lines, with the Federal aid road work to have the relations between the Federal Government and the several States in this large undertaking referred to so pleasantly as they have been by Mr. Coleman.

In speaking for the Bureau of Public Roads, I know that I can emphasize the effort that has been made by everyone connected with our part of the work to make the many details of cooperation as clear and as swiftly operating as possible, and just as it takes two to make a quarrel, it takes at least two to establish harmony, and no matter how great our efforts may have been we recognize fully that the States on their part have been considerate, patient and thoughtful to a marked degree in cooperating with us.

FEW DISAPPROVALS OF PROJECTS.

I shall follow Mr. Coleman's paper closely in this discussion and refer first, as he did, to the few disapprovals which have occurred in the history of Federal aid. Mr. Coleman had no objections to offer and said that the States themselves so far as his record showed were satisfied that the decisions were correct. To this might be added the other side of the matter, that with few exceptions we have known in advance that the States were ready to accept a disapproval before it was made, and in a few cases that information was voluntarily furnished us by the States. In this connection, however, it is very interesting to note that the dire word, "politics," has been associated with only one project that has come under our consideration. The routine of the bureau requires that all important correspondence between the district engineers and the States shall be forwarded to the Washington office for information. This is not an idle regulation because that correspondence is all scanned and some of it read with care. In one of our districts we were able to follow the events in this one case of politics very clearly. The field man had reported to the district engineer that it was quite clear that the location of the road and the selection of the project were entirely influenced by political considerations. The district engineer felt that it was not wise for this statement to appear in the record and informational correspondence which went over my desk indicated that the district engineer had written a short note to this field inspector returning the report and asking him to omit that statement or frame it in some other form. The report of the field inspector reached our office in due course attached to the project in question. Memory came to the rescue. The carbon copy of the informational letter was dug up and it was found that it applied to the suspected project. Obviously, the project was at once disapproved and so far there has been no aftermath.

Mr. Coleman cites a suggestion made by several States that an amendment should be prepared which would give the Department of Agriculture on the request of the State some latitude in the assignment of aid in excess of 50 per cent now allowed by the Federal law. From the point of view of cooperation between the States and the bureau, Mr. Coleman's suggestion answers itself. The department has neither the authority nor the discretion to allot funds in excess of 50 per cent and the only relief on this point is through Congress.

With respect to establishing different standards of construction for both highways and bridges in different parts of the country, there is this to be said: In the first place, the bureau has gone as far in this direction as it believes it can go under the present law. The large percentage of cheap work is actually in the States where cheap work appears to meet the current highway needs. The requirement of the law is not relative, but precise, and the bureau can not go much further than it has gone in approving the cheaper types of work. In this connection, also, it is interesting and perhaps amusing to note that on those roads which are eventually approved for lower types of construction, the first papers, apparently in an effort to make the road appear important, indicate a traffic which in many cases hardly warrants the construction of the type of road asked. Then when the type is brought into discussion, it is frequently pointed out that after all the traffic is not quite so heavy all the year round as the average cited would make it appear.

HANDLING WORK IN SECTIONS.

The suggestion has been made that for a long project some arrangement should be made for handling the work in sections. Such an arrangement now exists. It is possible to submit a project statement covering a road 60 or 70 miles long and have it approved as a whole. Later the road may be surveyed, plans and specifications and estimates made for it by sections, and each section or groups of sections in consecutive order or not at the option of the State may be put under agreement. Representatives of the States are referred especially to Minnesota, Illinois, and Georgia, in which States this arrangement is very common. At the present time there is under consideration by the bureau, and it appears now very probable that the bureau will be ready shortly to recommend to the Secretary of Agriculture, an amendment of the Standards Governing the Form and Arrangement of Plans, which will provide for second-class surveys. This arrangement will meet the suggestion of Mr. Coleman; not that the Government shall participate in the making of surveys and plans, but that the heavy items of expense, where clearing or new location is necessary, shall be properly construed as a part of construction and paid for as such. This arrangement presupposes the submission of a very simple survey on which approval will be based, and after the project agreement has been entered into the work of clearing may then proceed and complete plans be submitted later before payments are made. It is believed that this scheme will adequately meet the burden of objection to the present expense of some surveys. Figures which have come to our attention from the States of Kansas and North Carolina, and the cost of our own forest surveys, have convinced the bureau that under ordinary conditions the requirements of the present standards governing the form and arrangement of plans are neither onerous nor unduly expensive.

SPEED IN CONSIDERING PROJECTS.

The objection raised by most of the States that the acceptance of projects has been slow is perhaps a just one, although it does not seem possible under the present law to quicken it substantially. The bureau maintains the closest control over the field work of the districts through a monthly report and does not hesitate to be critical of its district engineers when the work received from the States is not expeditiously handled. It is a fact, however, that conditions are irregular. In some districts the record is first class and in others not so satisfactory. Our recent monthly reports show that over half of all project statements handled pass the district offices in an average of 5 days. Ninety per cent of the project statements pass the chief engineer's office in 4 days. Of the plans, specifications and estimates, over half pass the district offices in an average of 5½ days and about 90 per cent pass the chief engineer's office in 3½ days. Such delays as have occurred in the handling of plans, specifications, and estimates are the result of differences which are serious enough to be given special consideration. It is a fact which must be noted that the conduct of a project very often looks bad through no fault of the bureau. For instance, we are sometimes at a loss to understand how it is possible for a State to advertise, receive, and open bids, enter into a contract, and begin work before plans are available for our district engineer. This procedure occurs in a very large number of instances. If the plans for the work are sufficiently advanced for the State actually to begin construction, we think that they must be ready for the district engineer in a sufficiently complete form to be passed rapidly to approval. Obviously, no amount of effort on the part of the bureau can expedite the handling of plans which have not been received.

Mr. Coleman's suggestion that conditions will be still further improved, however, by placing a resident engineer in each State is the plan which the bureau has adopted as the probable remedy. In fact, such State representatives have already been placed in States where the work is sufficiently heavy to warrant it, such as New Hampshire, Massachusetts, Pennsylvania, Ohio, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Texas, Arizona, and others. In other districts, men are assigned by the district engineer to cover special States, but do not have headquarters in those States. In this list may be placed Florida, Tennessee, Michigan, Illinois, North Dakota, Montana, Idaho, New Mexico, and California. These men have authority to make the slight changes suggested by Mr. Coleman as desirable. The sizes of waterway, changes in the location of culverts, slight changes in grade and alignment, and even more important changes, providing they do not involve the Government in additional expense, can all be practically approved on the ground by the representative of the district engineer in the State. It is only necessary to carry these matters to the Secretary of Agriculture for approval when the changes are substantial in nature or involve the allotment of additional Federal aid.

DELAYS IN PAYING VOUCHERS.

Reference has been made to the delay in paying vouchers. Probably no detail of the Federal-aid work has given the bureau more uneasiness or consumed more time in its adjustment than the matter of vouchering. In the first place, it should be understood that the vouchering under the Federal-aid act is not provided for in the act in detail. It is covered by general fiscal statutes, and disbursements are made through channels in the usual way provided for other expenditures. The act goes no further than to say that such disbursements shall be made through the Department of Agriculture. Therefore, the system of auditing, the form of voucher, the itemized statement of claim, and such details, are all provided for by general statute and it is very difficult to secure any change. Federal-aid vouchers receive the same scrutiny and the same impersonal and routine treatment accorded personal expense vouchers of our own field men. If any of the State officials ever have worked for the Government and submitted vouchers under the fiscal regulations of the Department of Agriculture, it is not necessary to explain to them the minute detail in which all such papers are considered.

Very definite and careful instructions have been issued and the bureau has done everything it can to expedite vouchering and to insure that the States will receive credit for all the items in their claims.

If our instructions are carefully followed, vouchers can be passed rapidly without suspensions, but unless they are carefully followed it is very difficult to explain questionable details to the satisfaction of the auditors. Many of the instructions covering vouchers no doubt appear to the States needless and arbitrary. This is by no means so. For instance, the recommendation as strongly made as we can make it, that all overruns and underruns, and if possible the engineering claims, be deferred until the last voucher is solely made in the interests of the States, at which time these matters can be adjusted so that the States can use the 10 per cent as nearly at their discretion as possible. For, you see, the auditor has ruled that an item once entered as a contingency may never be replaced in the principal estimate. Two final vouchers under the same project agreement are not possible. Therefore, where projects under agreement are sectionalized and the States wish to close out each section separately, we ask them to voucher the sections separately. This and all of the other suggestions that we have made for vouchers are the result of fiscal rulings practically beyond our control, and our whole purpose has been to devise a scheme which, if followed by the States, will give them the least trouble and the freest hand in the matter.

AVOID SMALL VOUCHERS.

The last step we took in an effort still further to expedite vouchering was on October 4, when a letter was issued to all of the States requesting that they withhold vouchers until the claim was sufficiently large to require a payment of at least $1,000 Federal aid. This was done because we found that 35 per cent of the vouchers submitted to the office would involve less than $1,500 Federal aid and 30 per cent of them involved less than $1,000. The work of checking and auditing a normal voucher is practically as great for $100 as it is for $1,000. So it was felt that considerable relief could be had, both by the States in preparing vouchers and by the bureau in auditing, if the comparatively large number of small vouchers could be reduced. Some States expressed surprise at this request of ours, but it is a fact that we were receiving a considerable number of vouchers involving less than $250 of Federal aid and we have received them as low as $142. As a result of the suggestion made October 4, there was relief almost at once, and for this the bureau extends its most cordial thanks to the States. Out of 285 vouchers handled in October, 17 or only 6 per cent were under $1,000. In November, out of 303 vouchers only 5, or 1⅔ per cent were under $1,000.

All vouchers which have been in suitable condition for paying; that is, which have contained no uncertainties about which there has been correspondence, have passed the office in an average of 10 days. This covers checking, auditing, and all work from the time the voucher is received until it is scheduled to the disbursing officer for payment. It is surprising, however, what a large number of arithmetical errors we find in the vouchers.

WORK BEFORE PROJECT APPROVAL.

In connection with the vouchering, as in connection with the handling of plans and specifications, the bureau is sometimes at a loss to understand how it is possible for a State to have the authority to inaugurate construction, proceed for 90 days, and submit three intermediate vouchers, when apparently they have not authority to sign a contract with the Secretary of Agriculture for the prosecution of the work. When I left Washington numerous vouchers were being held on the desks until the execution of project agreements. In one State four or five different projects, involving from one to three vouchers each, were still without executed agreements. Our records show that the project agreements ready for signature were sent to that particular State in July and August, but they had not yet been returned. Of course no payments can be made until the formal contract with the Secretary has been executed.

It has been suggested that the States should be allowed to begin work before projects are finally accepted by the Department of Agriculture. This matter we believe has been pushed as far as it can be under the law. At the present time just as soon as the district engineer recommends that the plans for the project be accepted, the State may proceed with construction. The law as it stands is clear that the projects must be technically approved before, not after, work is done.

The bureau had hoped that the rules and regulations were reasonably clear, but Mr. Coleman suggests a revision to cut out repetitions and ambiguities. The States may be assured that if the rules and regulations are not clear, the bureau will not hesitate, on any of their specific suggestions, to remedy such defects.

These brief references cover the matters raised by Mr. Coleman, but before I conclude, I wish to take up one or two other matters indicating the value of cooperative effort and how it may be still further increased.

A STATE DEPOSITORY SUGGESTED.

In the first place, some States could further assist in the operation of the Federal aid law by selecting a State depository. If this is not now possible under the State law, the State highway department might well initiate State legislation providing a remedy. There are still nine States, which is nearly 20 per cent, that use county depositories, necessitating payments directly to county officials. The Federal law specifically permits this condition, but it is not convenient and leads directly to difficulties of administration in return for which there are no discernible compensating advantages. There have been some rather amusing incidents which have occurred in these nine States in connection with the county depositories. Not long since one of these unfortunate departments wrote to the bureau requesting revisions of the project agreements on 35 separate projects.

Now the number of revisions to agreements is causing us a great deal of work, much of which we consider unnecessary, and in this particular case there seemed to be no reason which we could see from a distance requiring such revisions. The county was the depository for each project. The State wished to make the State highway department the joint depository to receive only the amounts payable for engineering. A very simple method was suggested by the bureau whereby the State could secure as we supposed the same result much more easily. We suggested that all engineering charges for which the State desired to be reimbursed should be withheld and submitted on a final voucher. In this way all the construction items would be closed out in the next to last voucher and the engineering charges would stand alone in the last voucher. We suggested that an arrangement, which would be entirely satisfactory to us, could be made under which this last voucher would be mailed directly to the State highway department. The voucher payable to the county could then be submitted by the State to the county for endorsement and the State could deposit the warrant to its own credit. Very much to our surprise and somewhat to our amusement the head of the State department replied to us in a letter which aroused our deepest sympathy, saying that he felt very sure that if that last voucher ever got into the hands of the county officials they could never be persuaded to endorse it over to the State highway department. Under the circumstances, we felt that we must go to the trouble of making 35 revisions to help the State department out of its dilemma.

Another interesting case occurred in a Southern State. One day a gentleman called at the bureau with a very confidential inquiry. He wished to know what vouchers had been paid on a certain project. He presented what appeared to be adequate credentials to back up such an inquiry, and in fact he was a lawyer representing certain bond trustees who were handling cooperative funds on the project. Our record showed that a series of vouchers, some half dozen in number, had been paid on the project at regular intervals to the depository indicated in the project agreement. The gentleman returned to his home town and we later learned that the county clerk, acting for the county commissioners who were distinctly hostile in their attitude toward the bond trustees, had in fact received these warrants and placed them to the credit of the county commissioners instead of to the credit of the bond trustees. We hope that the bond trustees eventually got their money back.

We are receiving almost weekly, although only nine States are involved, letters either from our district engineers or from the State highway departments asking us when certain vouchers were paid. It seems that the counties receive the Government warrants and either fail to make clear records or fail to inform the States and the States are unable to find out what payments have been made except by coming to our office.

It appears quite clear that considerable jealousy, or perhaps antagonism, exists in some of these nine States between the State highway departments and the several counties, and the suggestion is made that a complete remedy could be had if the State law created a single State depository in all such cases. If the State highway departments could receive the warrants it would seem a simple matter for them to make the necessary payments to the counties.

ADEQUATE INSPECTION NEEDED.

There is one concluding matter, that I wish to refer to. I do not hesitate to take it up because I am confident that you will all understand the spirit in which it is done. I know that the representatives of the States concerned will recognize my allusions with both sympathy and entire agreement. Our reports show a decided lack of adequate inspection and resident engineering in many localities. It is by no means confined to the States that use county funds and depend often on county engineers, but the condition occurs occasionally in may different States. One of our district engineers, reporting a State engineer, has said to us that if no more Federal aid is ever voted, the administration of the present law has done enough to raise the standards of engineering, develop specifications, and insure the integrity of construction to make the present Federal aid worth many times the amount apportioned to the State. There are other States where through lack of funds or authority the State highway departments are tremendously handicapped in securing adequate engineering, both with respect to the quality of the personnel and in the mere number of men required. I quote from a recent inspection by one of our general inspectors, referring to a matter which the bureau has advocated from the beginning of Federal aid:

> "This is one of the first projects I have inspected in the State where thoroughly satisfactory relocation is being used. The old location, rambling directly up and down hills, with crooked alignment, is frequently abandoned for long stretches of relocation. Mr. ——— advised that, rather to the surprise of the highway officials, the new location was found cheaper than the old one. It also proved to be shorter, have much easier grades and better alignment. This improved location is entirely due to the new system being tried

out by the State this year under which all location surveys are to be reviewed with preliminary plan in hand on the ground by the division engineer and one of the headquarters construction engineers before plans are completed."

One of our field engineers, reporting to his district engineer, writes as follows:

"I took the opportunity of checking estimate on revised plans with original estimate in compliance with your request of October 28, 1919, and find a saving of $12,398.42 as follows:

Saving in excavation	$4, 906. 20
Saving in rock excavation	6, 477. 90
Saving in borrow	1, 014. 32
	12, 398. 42

As all projects have an additional 10 per cent added for engineering and contingencies, which would, in this case, be $1,239.84, we have a total saving of $13,638.26.

In making these changes the location and grades have been improved and the county and Government have been saved $13,638.26 through a careful study of the ground with plans in hand."

It would be possible to give many, many pages of such comment, but it is unnecessary to do so. You all in your respective States know the conditions even better than we do, and I will close my discussion by assuring you that the Bureau stands ready to do everything it can to assist where your engineering forces are weak, to make allowances in conditions of emergency, to adjust specifications so that they will harmonize with the abilities of your local contractors, the qualities of your local materials, and the general State practice in road construction. We recognize that the justification of the whole Federal aid program, nation-wide in its scope, depends first of all on successful road building, and to this end we are prepared to cooperate with the States to the fullest extent.

GENERAL DISCUSSION OF PAPER.

T. J. Ehrhart, state highway commissioner, Colorado: Let me speak of just two points that trouble us in Colorado in connection with our duty to the Bureau of Public Roads. With one we have already had to deal and one we can see we shall have to face in the future. Speaking first of the latter, all our funds are dependent on incoming taxes and we can see with our program there is a possibility of our not having funds enough on hand at some time, perhaps in this coming year, to meet the payments for the projects that are contracted for and on which work is being done. There is probably not more than $250,000 to our credit in the State road fund. We are paying out as much as $200,000 in a single month. Our funds for 1920 will not begin to come in until about the 1st of February. We can see that before the year 1920 comes around we might be in a position where we would not have money enough in our Treasury to pay the monthly estimates on the different projects at stake.

The other thing that had caused us a good deal of trouble already, and I presume every other State has to contend with it, is the advancing cost of material.

NEW MEXICO'S SITUATION.

L. A. Gillett, state highway engineer, New Mexico: I want to outline the problems the so-called public-land States face. Great portions of our lands are owned by a poor landlord—the United States Government. I will cite our own State, by way of example, because I know more about it. You must understand that New Mexico has practically 90,000,000 acres of land, only 365,000 inhabitants, and an assessed valuation, on the 100 per cent basis, of some $365,000,000. Practically 45 per cent of our lands are owned by the Federal Government and are not subject to taxation.

At present we have practically no roads, no built roads, I mean; but we are starting out bravely to build a system of 3,000 miles of primary roads, most of which are to be surfaced with gravel. Ninety per cent of this primary system is laid along lines of road which are used by travelers in passing through the State from other parts of the South and Southwest. Federal-aid money is going to be spent on that system.

We are already taxed almost 2½ per cent on the actual valuation of our lands to meet our general expenses, and the last legislature added 4½ mills on the dollar for road purposes, a tax which came within our constitutional limitation. But even that will not meet the full allotment of Federal money that is offered.

I submit to you that—building roads as we are, over 45 per cent of Federal lands from which we derive no benefit by taxation—it is not fair that we should be required to pay 50 per cent of the cost of such roads in order to meet Federal aid. We can not do it.

To illustrate the difficulty of our position let me cite the example of one county in our State. It is 150 miles long, and 90 per cent of the lands in it are Federal owned and yield not 1 cent of return in taxation. Just consider that problem for a moment. In that county, which is sparsely inhabited, the 4½-mill tax (which is a continuous tax) only yields $16,000 a year to apply on roads. It has one through-line road which is 115 miles long. Figure that out for yourself. The available funds are not sufficient for maintenance.

That is the reason for the resolution as to public-land States. It affects my State and the others of the 17 public-land States. We are asking that our proportion of participation be reduced; not for more than our percentage allotment. But we certainly do want to protect ourselves to the extent that we will be able to use all of the allotment and put it on this main-line system.

Federal Control and Aid for Highways— Its Results, Merits, and Limitations.

Thos. H. MacDonald, Chief United States Bureau of Public Roads.

A CAREFUL definition of the problem set up by this topic is essential to its discussion, and such a definition rests entirely upon a careful scrutiny and analysis of the uses which we are now making and which we will make in the future of our highways.

These uses may be defined roughly in four general classes: First, those uses chiefly related to agriculture; second, those which are recreational in character; third, those which are commercial; and fourth, those which are military. It is believed that these uses are placed in the order of their importance as determined by their respective volumes, considering traffic in the aggregate for all of the 48 States. Admittedly, there are sections, perhaps of some considerable area, in which the ranking order of these classes would be changed, but conceding this it does not modify the principle that the roads which we are building must serve these four classes of traffic, and that a failure to provide adequately for any one of these classes means a shortcoming, at least, in the methods adopted by both the States and the Nation; so those laws which we now have must be judged in the light of the degree to which we are now providing, or, if given sufficient time, will provide, for these classes of traffic; and certainly provision for these classes is the whole object of the enactment of either State or National highway laws, or the establishment of State or Federal highway departments. This statement should be reiterated until the attention of road builders is focused upon the proper objective. It sometimes would seem that we are likely to lose sight of the object we are attempting to obtain in discussing the manner or the means through which we shall operate, and at such times it seems highly desirable to analyze in some detail the uses of the roads for which we are attempting to provide.

THE SERVICES OF THE ROADS.

The first class—those uses related to agriculture—includes the town-to-farm and farm-to-town traffic characteristic of the more purely agricultural districts, the country-to-city and city-to-country traffic, which is fast-growing and highly important where adequate roads have been built radiating into the country districts from the large centers of population, and the traffic carrying crops or food stuffs from productive areas which are isolated from rail transportation. Under this class should also be included the social, educational, and religious activities which produce traffic from the farms to the schools, to the churches, and to the community centers.

The second—the recreational class—includes two distinct types of traffic, local and tourist. Local recreational traffic is continuous, and is not definite in its character. The automobile has been the means of combining a great deal of business and pleasure, and of the two kinds of recreational traffic the first is far more important, because it affects so much larger a percentage of our population, and the recreational value of the continuous outdoor driving, and the increased social intercourse which has resulted, can scarcely be estimated in their effect upon a large percentage of the population, whose social and recreational activities up to the advent of the moderate-priced motor car were very limited.

The tourist traffic is a growing and highly important one, and this growth should be enlarged by providing adequate roads, so that interstate and transcontinental traffic will be encouraged. There is not a single State in the Union that does not possess a locality of interest to the population both within and without the State. There is perhaps no better way to promote a broad Americanism than to make it possible, through the building of roads, for the people of one State to know in a more or less intimate way something of the worth and beauties of the neighboring States, and this interest and knowledge should be sufficiently extensive to take in the National parks, forest areas, former battlefields, and the many points which, through historical association and tradition, or because of their natural characteristics and environments, hold much of value to every man who places his country above all others. While traffic that may be included under the term "tourist" is fast growing, it is very small in comparison to the other recreational uses that are being made of the roads, and it is impossible not to foresee that this class can never be more than a minor percentage of the local recreational use of the highways. During the season of 1918, 54,596 private automobiles entered the 11 National parks, while during the same season approximately 450,000 people visited these parks. These figures may be taken as indicating something of the tourist travel by highways when it is considered that a large amount of our western automobile travel makes the National parks its objective; but considering that this traffic is spread over a period of several months, it will be seen that if all of the automobile travel were confined to a single road, it would then only equal a daily traffic equal to that on many country highways outside of the influence of any large city, and would not begin to compare with the traffic on our heavy-traveled thoroughfares in populous districts; but considering that the total number is spread over many western roads, it will be seen that this traffic is only incidental to the local uses which are made of the main thoroughfares.

The third class—the commercial use—is not strictly defined by this term, but as used in this discussion refers to the traffic on the highways resulting from the transportation of commodities between centers of population as differentiated from the collection of crops and distribution of commodities in the rural districts. This class of traffic would cover the carriage of commodities, much of it in package form, which now makes up the bulk of short-haul freight and express. No doubt there will be a very large increase in this class of traffic on the highways, but the traffic which developed during the war is not normal and will not continue as the normal conditions reassert themselves. Just what will be the length of haul which, because of its economy, will go to the highways, has not yet been determined, but the only studies made by the bureau, and these during the period of the war, indicate that 100 miles seems to have marked the limit of such hauls. Even conceding that this class of traffic will develop very largely, it must of necessity be confined to those areas where the terminal points, consisting of comparatively large centers of population, are close enough together to allow at least daily one-way trips of the unit of transportation used, and our studies indicate that the limit is being reduced to perhaps 50 miles. It is not intended to overemphasize this limitation and is useful here only to point out that such studies as have been made up to this time indicate this fact.

The fourth—the military uses of the highways—is given fourth place not because of its lack of importance, but because the probable strictly military significance of the highways has been very considerably misunderstood. Any system of highways which will serve the first three classes of traffic will adequately serve the military requirements except in certain particular areas. In such areas the highways must be provided which are demanded by the military authorities as a part of their plans for their military operations, but it must be accented that military highways as such are confined to restricted areas, and, outside of these so-called vital areas, any system of highways that adequately serves the agricultural and commercial traffic will serve also the military purposes in either war or peace times.

LARGEST USE OF ROADS LOCAL.

If, therefore, it is conceded that practically all of the traffic which we are now carrying on the highways has been defined in the foregoing classes, it is at once evident that, with the single exception of tourist traffic, the uses of the roads are largely local. There are no traffic counts which have been made sufficiently extensive to indicate that a general statement may be made that will correctly represent by percentages the use of the roads that is local, but those traffic counts which have been made would place this use as high as 90 to 95 per cent, and it is very questionable if this percentage will decrease very materially even as the roads are improved, for, although the total traffic on improved roads increases rapidly, it is doubtful if the average daily local traffic will fall below 90 per cent, except on those roads which, because of their particular location, are built primarily for tourist travel.

These statements, it must be remembered, are intended to be very general in their character, and to cover the country as a whole, but it must be conceded that more than 90 per cent, and possibly more than 95 per cent, of the demand for better highways arises from the local need for such improvements. The developments of a national highway system must therefore take this fact into consideration, as opposed to the development of a system of national highways. There would be no advantage gained by considering the local uses of the roads as secondary. No plan of administration predicated on such an assumption can prevail, because it is an economic fallacy. That there is a demand for better facilities for tourist travel there can be no doubt, and that there is an increasing demand in localities for better facilities for through transportation of commodities is equally apparent, but that these needs now justify national intervention solely in their behalf or that they are of such a nature that they can not be met by a properly planned national system of highways is open to serious question.

There is no evidence of fact shown by traffic counts, or any highway use of importance, that justifies a presumption that a need of national consequence is being overlooked. Now that we have the public support of a program of expenditures that will enable every highway building organization to proceed as rapidly as the material resources can be developed, we must meet in the development of our highway systems the economic needs of the Nation for highways in the order of their importance. That these highway systems must be laid out along sane and sound economic lines is all the more important when it is evident that such a procedure will eventually produce systems of highway suited to the special needs of each locality, and yet be entirely adequate to meet all the requirements which those who are particularly interested in a system of national highways specify.

ROADS AND FOOD DISTRIBUTION.

At the present time there is no more important problem confronting the American people than that of increasing the comfort and desirability of rural life, thereby stimulating the production of food products, and of equal importance to this is the necessity for providing better methods of distributing food products, and especially the perishable food products, to the consumer without loss of time and without these products passing through so many hands between the producer and the consumer.

Federal intervention through Federal aid, if of assistance toward these ends, is reasonable and proper from such standpoints alone; indeed, such intervention may be said to have become imperative. The city population of this country has for years been growing rapidly, while the growth of the rural regions in many places has been negligible, and too often has been actually negative. The towns have held too many attractions in the way of social, recreational, educational advantages, but through the use of the motor car in conjunction with improved roads, these advantages in favor of town life can be largely overcome.

Beyond any doubt the war accented the need for more and better highways during the period of rail congestion, but if there is one need that the after-war conditions have brought close to every individual in the Nation, it is a need for an adjustment of conditions that will allow people to be properly fed and clothed within the limits of their incomes; and so far as improved highways will help to accomplish this, they certainly will be held to fill a great national need. The population of the country has more than doubled since 1880. At that time only a little over 30 per cent of the population was recorded by the Census Bureau as urban, or some 16,000,000 out of a total population of 50,000,000. Today out of a total population of approximately 105,000,000, about half, well over 50,000,000, are urban dwellers. The effect of this condition is reflected in production figures. In 1880 the production of wheat was about 450,000,000 bushels per year, while during the period prior to the war it was only slightly over 700,000,000 bushels. Similarly, in the case of corn, the production in 1880 was about 1,700,000,000, while prior to the war it was about 2,500,000,000. War conditions as to production were abnormal, so prewar figures have been used instead of the later figures. From these figures it appears that the production of food has increased about as the rural population has increased. It is true that there has been some gain in the production of the individual on the farm, but the fact still remains that the total population has been increasing much faster than the rural population, and any effort that the Federal Government can make to improve rural conditions that will insure a sufficient rural population, and to provide means for bringing the producer and the consumer closer together, is justifiable, and from this standpoint alone Federal aid for roads can certainly be considered to be at this time of great national assistance in one of the greatest national problems which we have.

BIG RESULT OF FEDERAL ROAD ACT.

The results accruing from the Federal aid road law up to the present time, because of the conditions during the period from which we are just emerging, can not fairly or honestly be reckoned in the number of miles of finished road. The big result, so outstanding as to overshadow every other consideration, which can be primarily credited to the Federal aid road act, is the amount and character of advanced road legislation which has been written into the laws of every one of the 48 States. These laws, in connection with the Federal aid road act, have established on a firm basis, with adequate support funds, highway departments in all of the States which did not have highway departments prior to 1916. In the States which had highway departments prior to that time the legislatures have enlarged and strengthened the authority and increased the support funds of the departments. This legislation has in general provided for more than the building of the Federal aid roads, and in some of the States has included provisions for the building of the roads from the greatest to the least important. In addition to the legislation, great sums of money have been made available through the levying of special or general taxes, and through the authorization of bond issues.

The Federal aid law should not be credited entirely with this changed viewpoint on the part of the public interested, but it can be credited with appealing in a most forceful way to that characteristic of the human race which is perfectly willing to exert itself greatly to secure some reward. Probably without Federal aid the conditions after the war and the changed attitude of the public generally toward public spending on a large scale would have made themselves manifest, but certainly the Federal aid road act can be credited with having turned the attention of the public toward the expenditure of public funds for highway purposes.

It was not possible to go ahead with the actual production of roads on any considerable scale during 1917 and 1918. During the present year a large mileage of roads has been placed under contract, but the production has still been disappointing, due to conditions which are now well understood; but during this period there has been a remarkable development in the fixing of systems through the classification of roads, so that now we have in each State a system of main or State roads more or less definitely fixed, and in many of the States other systems of lesser degrees of importance. Many of these systems have been worked out very carefully and painstakingly, in fact it is doubtful if the highest administrative and executive officers of the State highway departments have devoted as much of their personal attention to any other single phase of the highway work as they have to the actual classification of roads. For the last three years this has been perhaps the chief and most important work that these men have accomplished, and its importance should not be underestimated.

FEDERAL AID TO STATE SYSTEMS.

The proper classification of roads is basic and fundamental, and it has been demonstrated in those States which have carried out this classification in a careful, thorough manner, that people acting through their State legistatures have provided the ways and means for carrying out the program of improvement in accordance with the importance of the roads. Let it here be clearly understood that the people of this country will support a policy of road building which is based on their economic needs. It has been pretty well demonstrated in individual States that the mileage of the primary State roads can not be restricted to too small a percentage of the total. Most of the States have found it necessary to add to their original conceptions of an adequate system a considerable mileage, and where this action has not been initiated by the State highway department itself it has resulted through legislative action. It has been pretty definitely established that a system of primary roads must be sufficiently extensive to give service to all parts of the State. It is hardly safe to fix the percentage without further inquiry, but it seems evident from the result in States which have made a careful study of their economic needs, that in the neighborhood of 5 to 7 per cent of their total mileage will be included in their primary systems. This percentage may change slightly for the Nation as a whole.

Unquestionably at the present time Federal aid should be restricted to the State systems, and since it is true that the State primary systems can in general be divided into roads of first and second importance, it might serve the economic needs of the States to confine Federal aid expenditures to the roads of the first class in the primary system. It is likely that this will be more possible in the older States than in the newer States where it is absolutely necessary to develop a considerable mileage of roads in order to give the people access to all of the different sections of the State. That is, there are some sections in which a smaller mileage of high class roads is necessary to meet traffic demands, and there are other sections in which a longer mileage of cheaper roads will as adequately serve the traffic needs, and which is the only policy that the public will support at the present time.

CONNECTING PRIMARY SYSTEM.

The step which seems necessary now is a definite plan of cooperation between the States and the Federal Government, which will insure that the primary systems of each State are connected up with the primary systems of the adjoining States, and that these systems, by agreement between the State and Federal authorities, be held to until they are properly improved.

Up to the present time the Bureau of Public Roads has made its objective the perfecting of the administrative relations with the States. These relations have in general been placed on such a basis that better engineering standards can be developed and enforced, and it is undoubtedly a duty of the Federal bureau to stand behind the States in their efforts to provide roads that will be adequate not only for present traffic but for future traffic. This point is of great significance, particularly in those States where roads are being built from bond issues and where it is doubtful if adequate maintenance funds will be provided for those types of roads which will require high maintenance cost.

It is true that the Federal aid act requires the greatest cooperation between State and Federal authorities in order to make the plan outlined by the law an efficient method of operation, and yet it has as its fundamental basis a plan of action that will have to be used more and more in carrying out large public or private enterprises that are undertaken in this country, and the sooner this fact is recognized and put into operation the better it will be for the industrial life of the Nation.

There is now comprised in the 48 State highway departments and the Federal department a very large proportion of the engineers of this country who have had actual highway experience, and these agencies can, through cooperation, provide the most effective administrative organization that it is possible to devise. The fact that a considerable portion of these administrative officials are in close contact with the public in all the different localities of the Nation, insures the development of the roads which will answer the greatest economic needs.

MODIFICATIONS IN FEDERAL LAW.

In the law itself there are certain modifications which undoubtedly should be provided for the extensions of appropriations for carrying out this act. One of these is the $20,000 per mile limitation, which is not now so much of a handicap but may later become so. There are roads being built where the grades themselves, because of the topography, will cost without surfacing nearly up to the limitation now imposed by the law. After these road grades are properly settled they should be surfaced where the traffic justifies.

In many of the sparsely settled Western States there are large areas of federally owned lands through which the State systems must be projected, and in many cases the roads through areas of this character are necessary links in trans-State or transcontinental lines. To prevent an undue burden falling upon the States which can ill afford to build such roads, consideration should be given to the extension of the appropriations which are now made for the building of roads in the forest areas. These roads in general are of two classes—those which are necessary for the administration of the forest areas themselves and those which form important links in the State systems. Again, there are roads notably in the Western States, but found also in some other localities, which are of greater importance as links in trans-State or transcontinental lines of travel than they are to the immediate locality.

If the States in which such roads occur follow a program of providing first those roads which meet the greatest economic needs of their people, some of the through roads will necessarily be delayed for some time, and the advantage of a long line of improved roads on either side may be largely lost because of such unimproved stretches. To take care of cases of this kind consideration should be given to a provision which will allow the bearing of a greater part of the cost from the Federal-aid funds than the 50 per cent now specified. Such procedure would undoubtedly be fair and reasonable, but if adopted it should be carefully restricted and guarded so that the roads which ought to be improved as links in long lines of travel will receive first attention.

These points summarize the most important modifications which it seems now necessary to make in order that the present Federal-aid law, through cooperation between the State highway departments and the Federal Bureau of Public Roads, may meet satisfactorily the National need for improved roads, and insure the completion of roads in the order in which they meet the economic needs of the individual communities and of the whole Nation.

Making Highways Ornamental and Useful.

JOHN A. HAZELWOOD, Chairman Wisconsin Highway Commission.

OF ALL the constructive work that is done, there is none that counts more in obtaining good results than the planning and preparation that goes before the actual performance. We realize that good roads lie at the basis of social institutions and the associational life of every community. Good and attractive highways can not possibly be obtained unless they are planned.

The period of achievement in the road work is not over, but we are entering upon new phases of the problem, mainly because we are seeing things in this motorized age in a different light. We are in a new era of social development and national growth and the question is not whether we shall continue to expand but how we are to expand. On some things we have spent too much time and wealth and on others we have spent too little. Those things upon which we have wasted too much are easy to criticize because we see the mistakes, but those things upon which we have spent too little may have caused great losses, although they are not especially apparent. Wealth is produced not from the existence of natural resources, but from the conversion of natural resources into some form of human use. The æsthetic phase of road betterment does convert natural resources into forms of human enjoyment and should be encouraged.

BEAUTY IS WORTH WHILE.

It is not enough to build good roads, it is not enough to maintain good roads, it is vitally important when we build and maintain good roads that we beautify them. Roads without embellishments, such as trees, shrubs, and flowers, are ugly and prosaic. It is not enough to consider only the financial side of roads; it is our duty to consider as well the joy that man receives traveling upon them. Any progressive and self-respecting community ought not to allow a mercenary spirit to cause it to disregard the work of beautifying highways. Rural forces should make "Scenic betterment" one of their slogans. All over the New England States we find, in connection with trolley lines, comfort stations with trees, shrubs, and flowers about them, cared for at the expense of the railway companies. We find in many of our cities small parks with shrubbery and flower beds about the railroad depots. These companies do these things because they know they are rewarded for so doing. Rest rooms and comfort stations at regular intervals along the roads add greatly to the joy and comfort of traveling.

We have been careless and thoughtless in the past. We have permitted the woodman's ax to destroy the trees we have admired as bits of forest scenery.

PLANT TREES, SHRUBS, AND FLOWERS.

We should plant trees, shrubbery, and flowers along our highways. What a splendid opportunity we have for getting good results from nut-bearing and fruit-bearing trees systematically planted and cared for along the public highways of this country. The expense of planting trees, shrubbery, and flowers along our roads and caring for them calls for only a small expenditure of funds. We should realize that each passing year will add to our pleasure if trees and shrubbery are planted and protected. Little do we realize the returns obtained from this class of service which are not considered in Wall Street or listed in Bradstreet.

We all admire a home with trees, shrubbery, flowers, and trailing vines about it. We know the pleasure that is excited in hearts by these adornments. We can not help but feel sorry for those who are obliged to occupy homes where no attention is given to plants, to flowers, and to trees. A little attention to flowers and trees will transform ugly lawns into spots of beauty. We can not look upon a beautiful tree or a cluster of shrubbery without forgetting a grouch and getting an inspiration for higher thinking. The shade and the freshness of trees along the roads running out of any village or city are needed now more than ever before. Concrete roads and hard-surfaced roads of all kinds are cold and need some softening effect.

BEAUTY AND PROFITS.

Beauty and profits usually do not go hand in hand. However, beauty is ofttimes combined with utility and this is true in road building. One can note at a glance whether a road has had the touch of an artist. A curved road is much better adapted to artistic landscape than a straight one. If to this curved road are added the touches of the tree, the shrub, the flower, we have pleasing associates as we travel along. It does not take a landscape gardener to tell whether thought and attention has been exercised in connection with highway construction.

We are all interested in civic art. We like to put out best foot forward. Civic art means a constant endeavor to secure in our public works the maximum of utility combined with the maximum of beauty. Cities have realized the importance of this and have given large attention to parks, playgrounds, and boulevards. In fact, proper attention to roadsides means a definite increase in the pleasure of traveling and a substantial addition to the value of adjoining property. Cement, macadam, and gravel roads particularly need the protecting shade of trees.

BEAUTIFICATION WORK.

We know that many European countries have spent and are spending large sums of money in planting and caring for trees along the highways. Many trees along highways are apple, plum, and cherry, and from these large profits are annually obtained. The southern counties of the United States have given some attention to the matter of beautifying the sides of roads. The counties, particularly of Florida, have expended lots of money in beautifying their highways. Los Angeles County, Calif., spends annually $7,000 a year for the purpose of planting and taking care of roses along the highways.

The beautification of one country road in Los Angeles County has recently been completed. The road, which is known as the Sherman Way, extends 28 miles through an agricultural district near the city of Los Angeles. The district was originally embraced in a 47,000-acre ranch, which was taken over by a real-estate company, and about three years ago the work of beautifying the road was undertaken. It was completed last winter and the road formally turned over to the county, which in future will maintain it. The beautification has consisted of the planting of rosebushes and trees along the roadside. The rosebushes are planted at intervals of 7 feet along each side of the road. The different varieties of roses are grouped together. In all, there are approximately 80,000 rosebushes. The total cost of this work was practically $100,000.

Many other counties in California are annually spending large sums of money in beautifying their highways. These investments are paying well, and the counties that have had this experience in beautifying their roads realize this and intend to continue to expend money on landscape work.

NEGLECT OF ROADSIDES.

We have been a little careless in the road game of late. Many road builders have destroyed beauty by permitting the careless cutting out on the side of roads of the blackberry, the hazel brush, the wild rose, and the wild crab and thorn apple. The transformation of many roads by our so-called professional road builders from the rustic, beautiful drive to the barren highway seems almost brutal. In many cases everything has been grubbed out. Bare spots mark the places where beauty went up in smoke and flame. This change from the beautiful to the ugly has not been called for and should not have been permitted.

One distracting thing along the country highway is that of advertising. We see the billboard destroy the beauty of many pretty glens and beautiful curves. The greed of advertisers has destroyed many beauty spots by putting up advertisements of liquor, patent medicines, tobacco, and corsets. This destruction of beauty has been somewhat handled through city ordinances issuing permits or licenses. Women's clubs in our cities have done much in the matter of curbing landscape destruction by billboards. Little has been done in rural districts to restrict such advertising.

It seems that the most effective way of handling the question is the exacting of a tax. I believe we could drive away much of our advertising on billboards that can reach the eye of the traveling public. In order to not be unduly hard on those who have already erected their billboards, half or quarter the rate might be charged them until they take them down or have them repainted. This is one of the effective ways of handling this manner of destroying the beauty of our highways.

NEED OF LANDSCAPE ARTIST.

Every highway commission should employ a landscape artist. Delaware has already taken that step. There should be a landscape artist abroad in the land. Nothing counts like expert advice and direction in the handling of important problems. We can not afford to let this matter of rural planning continue to be worked out under our indifferent amateur policy if we wish to make our roads ornamental as well as useful.

We all enjoy a beautiful road and drive. Nothing is more pleasing to pass over than a road stretching ahead, running by farmhouses, wayside schools, churches, and villages. The automobile has crowded two, three, and even four hours into one hour as compared with the horse-drawn means of transportation. A road seems to have moods and whims. Sometimes it stretches on and on into infinite space; sometimes the eye loses it in some wistful curve; sometimes it loiters in sunny vale.

Some one said, "The important thing to me about a road, as about life, is not that it comes from somewhere and goes somewhere, but that it is livable where it goes." The invitation to explore the unknown road is very alluring. The unknown road as it winds along is a perpetual revelation of beauty. One person rightly says that he greets a new road with almost as much pleasure as a new person and usually parts with it with rather more reluctance. It is curious, indeed, how closely roads are linked with humanity; how warmly companionable they are. A public road talks business all the time. It tells us new things about everything that appears in a panoramic view on the roadside. It tells about the farm homes and the type of farming that is being carried on by the owners. It is one of the most important and interesting of all of man's wonderful institutions.

BEAUTIFUL ROADS ARE EDUCATORS.

We never receive our friends in our woodshed and break bread with them in a corner of the kitchen, using our ordinary linen, silverware, and dishes, but we receive them and entertain them in the most comfortable rooms in our home. We dine them in our most pleasant room and we use our best linen, silverware, and dishes. What for? Why, for the very purpose of impressing upon them that we are maintaining good homes. Our visitors are usually our friends. They bless us and make us happy and contented. Therefore, we are justified in spending a great deal of time and money in providing attractive lawns, beautiful entrances, and pleasant homes. The portals, the gateways, the entrances to our community homes are the highways.

Many of our cities understand the value of having inviting boulevards and streets for guests to enter. Large attention is given to the main entrance to commercial and residential centers. They beautify the streets with park rows, with trees, hedges, shrubbery and flowers so that visitors may feel more welcome. Rural communities should take the same interest in their roads. They should not only build and maintain roads but they should beautify them to give their friends a good impression of their homes.

We find many so-called self-styled "practical men" who do not realize the importance of beautifying country highways. Lloyd-George said that there is nothing more fatal to a people than it should narrow its vision to only material things. We need beautiful streets and highways to stimulate the imagination and exalt the vision of our people. We know that good roads mean good schools, education, and prosperity and that bad roads mean poor schools, ignorance, and poverty. Beautiful roads are silent educators. Each beautiful thing makes a good and lasting impression upon the plastic mind of man, and when we consider that an ugly road makes the opposite impression we should realize our responsibility in the matter of adornment of our highways.

NEW TEXAS ROAD MATERIAL.

Ten miles of road outside of Rockport, Tex., according to the State highway department, is being surfaced with a material which analyzes more than one-fourth epsom salts. The material is obtained from flats where constant evaporation of gulf water has left silt strongly impregnated with salts, among which the epsom variety predominates.

Highway engineers declare the mixture forms an excellent road surfacing material, as the salts absorb enough moisture from the air to keep the roads damp, free from dust and firm on the dryest days. One trouble, however, is that the road becomes very slippery during wet weather, but this is overcome by adding a small proportion of shell and regulating the the slope of the surface.

SPOKANE, WASH., ROADS.

Spokane, Wash., plans to build about 32 miles of permanent highways this year under the county program as outlined in the recent $3,225,000 road bond issue. They will cost about $425,000, or about $12,500 a mile. All surveys for these roads have been completed and it is expected that the contracts will be let before the construction season opens.

Design of Highway Drainage Structures.

CLIFFORD OLDER, Chief Highway Engineer, Illinois.

IN discussing such a question as this, I presume all of us talk from the point of view of our own State, modified by the injection of a little idealism. So I shall talk largely from the point of view of Illinois.

As the result of a number of years of study we have adopted, in Illinois, a standard width for graded or trunk line roads of 30 feet from shoulder to shoulder. Of course, we make exceptions to the rule where we encounter difficulties or extraordinary expense, but the width usually is 30 feet. Our bridge widths are related to this standard graded highway width.

WIDTH OF THE STRUCTURES.

We define drainage structures with spans of less than 8 feet as culverts; those with spans over 8 feet in length we call bridges. All our culverts are built the full width of the highway, so that the roadway is as wide over the stream as at any other point. The larger structures are not built so wide. That is the general, not the invariable rule. As a large part of the land in our State is prairie land, there are districts where one can ride mile after mile and pass only an occasional drainage structure over 8 feet in span. On such roads we frequently depart from the general rule and build all the structures of less span than 30 feet to the full width of the roadway.

Of course, we should like to have a traveled way without restrictions of any kind, but we have not been able to bring ourselves to that point yet. In the matter of long-span bridges, we think in dollars and cents, and we cannot consider the idea of doubling our bridge expense, which is already heavy, even to secure an unrestricted roadway.

Speaking, incidentally, of prices, it has been interesting to me to note that while road work has about doubled in cost, bridge work costs three times as much as in prewar days. For a period of 5 years preceding the war structural steel averaged a little less than 3 cents a pound. At present, we are paying more than 9 cents per pound, or three times as much. The average cost of reinforced concrete bridges and culverts during a 4-year period prior to the war, was $12.50 per cubic yard, including the steel; now they cost from $20 to $30 per cubic yard, and the steel is paid for as an extra. In our State more than 90 per cent of our structures are of this type. We are giving considerable thought to the problem of reducing the cost by revising the standard designs of a number of years ago, eliminating excess material wherever possible.

CLIFFORD OLDER.

On the long-span steel bridges we have been following the practice of substituting for the customary concrete floor a floor of creosoted block on creosoted plank as a supporting element, and we find that we effect a saving in the weight of structural steel which will more than pay the extra cost of the creosoted blocks and plank as compared with concrete.

ONE-COURSE CONCRETE FLOORS.

We have changed our policy in regard to concrete floors. Formerly I was firmly convinced of the need of building the concrete floor of a steel bridge in two courses, with a distinct plan of cleavage between the upper or wearing course and the lower course, which I considered as the supporting element, so that we could entirely wear out the wearing element without affecting the strength of the supporting element.

However, after long experience with concrete roads (some of them built 8 or 10 or 14 years ago) we have now come to the conclusion that the wear of a well-built concrete wearing surface under auto traffic may be practically disregarded. So we have changed our practice. We are now building our floors in one course, adding 1½ or 2 inches to the thickness of the former supporting slabs and abandoning the independent wearing surface entirely. We find that the change is in the interest of economy, because it was necessary formerly to build the wearing course at least 4 inches thick, or if thinner to reinforce it to prevent cracking.

The matter of bridge loading, and pavement loading as well, has been greatly simplified in Illinois since the last session of the Legislature. We were fortunate enough to be able to pass a law regulating the weight of vehicles which may use our rural highways, and, indeed, our city streets also, with the provision, however, that the city governments may increase the loading specified by the law by as much as 50 per cent, if the council so desires.

LIMIT ON THE LOAD.

We now limit the loads to 16,000 pounds per axle. We thought at first we should like to have a wheel-load limitation, but we found that such a limitation would get us into difficulties with the truck manufacturers, and as we felt that very few vehicles would be symmetrically loaded, we concluded to consent to the limitation of axle rather than wheel load. The gross load of the vehicle is not specified. It may be any amount, providing no axle load exceeds 16,000 pounds. Under the new law, if a motor truck could be designed to distribute its load equally to each of its four wheels, the gross load of the vehicle might be 16 tons. But in many cases the gross load of the vehicle is not the critical factor; the wheels are far enough apart to act practically independent of each other on a pavement surface.

Before this law was passed any load a man might choose could be carried over a pavement or bridge. A brick house might be moved down the road, as they actually did in one case, in absolute disregard of the strength of the road or bridge. Such objects may still be moved over the highways with special permission of the road authorities having jurisdiction. Of course that means, in the case of practically all paved roads, the division of highways, or department of public works and buildings.

Our practice in designing concrete bridges in the past has been to provide for the equivalent of a 24-ton steam traction engine or motor truck. In proportioning the bridges we have allowed a compressive stress of 1,000 pounds per square inch. We have built bridges designed in accordance with these assumptions, and 12 years' experience indicates that they have been safe. Our practice in this respect has been criticised, but we have never had a failure of one of these bridges. However, for such structures, in view of the stress we allow, we shall probably adhere to the old loading.

As an alternate to the 24-ton concentrated load, we provide for a distributed load of 125 pounds per square foot, if the distributed load produces a greater stress than the concentrated load, which it does on spans of more than 28 feet, I believe.

We feel that our bridges are seldom, if ever, subjected to these maximum loads. When we adopted the 24-ton load limit we had steam plow engines that weighed that much. But those have gone out of fashion, as have nearly all the steam tractors, and they have been supplanted by gas or oil tractors which weigh only 10 or 12 tons. The maximum distributed load is also rarely, if ever, attained. So far as I know the nearest approach to the equivalent of such a load, which our bridges have ever been called upon to carry has been a heavy tractor and a train of Troy trucks. But such a train is rarely over 50 feet in length, and even such a load does not produce a stress in a 150-foot bridge which approaches the stress assumed in the design.

Furthermore, suppose that 1,000 pounds per square inch does equal one-half the ultimate strength of the concrete, experiments with loads indicate that we actually do not exceed one-half of the ultimate strength. It would require several thousand, or several hundred thousand repetitions of such a load in order to cause the structure to fail under compression; and the ordinary highway bridge will have been washed out or destroyed by tornado or fire before the maximum load will ever be sustained 1,000 or 5,000 times.

The use of the high stress enables us to design economical bridges that span from 60 to 65 feet.

ORNAMENTATION OF STRUCTURES.

Ornamentation is a subject upon which it seems that every one has his own ideas. Early in the game we found great difficulty in inducing the people to pay for ornamentation, but, of course, when we furnish our own funds we can do as we like. For some years we have thought we were designing fairly sightly bridges; at any rate we had concluded that our bridges were not unsightly, until a convention of architects met in Springfield and told us we knew nothing about it, that we were designing hideous structures, eyesores, and all that sort of thing. But as architects and artists differ as much as engineers among themselves, I believe we have as much right to our opinion as they have to theirs.

Indeed, I believe that the engineer who gives some study to the appearance of his structure is more likely to produce a bridge which will please the public than the architect, who is apt to use too much gingerbread. We have some architecturally designed bridges in Illinois, and to me they are decidedly not pleasing structures.

In our bridge designs we attempt no useless ornamentation. We believe in the beauty of proportion and simple lines, revealing the structural features. Personally, I do not believe in making a girder bridge look like an arch by putting false curved walls along the side. Anybody who has ever seen an arch can tell it is not an arched bridge. When we design a girder bridge we intend it shall look like a girder bridge. If it is an arch, we do not attempt to deceive the public into the belief that it is a girder. Of course, everyone has a right to his opinion in such matters.

There is one thing that we have found, and that is that we have been mistaken in the amount of camber we have been putting into steel structures. We have always decided how much to use by means of side-view drawings, and we have been led, thereby, to use too much. We find that the camber which seems to be right when viewed from the side appears to be excessive when one looks down the roadway and sees the hump in the arch. And as 97 out of 100 people see the bridge between the rails rather than from the side, we have gradually reduced the camber, until now it is something like an average of 4 inches to 100 feet for a series of spans.

DISCUSSION OF MR. OLDER'S PAPER.

William F. Cocke, assistant commissioner, Virginia: The subject Mr. Older has talked to us upon will cover, I think, these four headings, which I would group in their relative importance as follows: The first and most important feature of a drainage structure is: Strength, capacity to carry the loads regardless of its adequacy of size. If it is not strong enough, though sufficiently large, it will be dangerous. The next most important feature is: Adequacy, sufficient area to carry away the water that will go through it at high-flood time. Third. Durability; we want to build something that will be durable. Fourth. Appearance.

It strikes me that Mr. Older is leaving two very important factors out of his calculations when he figures on a design that will give 1,000 pounds to the square-inch compression. Those factors are inferior material and inefficient inspection. I do not question Mr. Older's theory at all. But I do know that in a great many sections of the country we have to put up with inferior materials, and in the present condition of the market for engineers and inspectors we have to put up with unknown quantities in the way of inspectors. Taking those two points into consideration, I personally would be very dubious about attempting for the State a work following a design with the stress he recommends.

I believe in a great many instances a designer labors either under misinformation or inadequate data in regard to conditions under which the construction will have to be carried on. I know I have been just as guilty along that line as any other field engineer, and I don't think that time or expense should cut any figure in securing the necessary data on which a design for a structure is to be based. I have in mind an instance which occurred within my experience in the last two years where approximately $300 additional expenditure in collecting the preliminary data for a $200,000 structure would have saved a good deal of embarrassment, and possibly some unnecessary expense, in connection with the construction as it was actually carried out.

I think that soundings are not always adequate or sufficient in testing the foundations for large structures. In a great many instances, where the structure is on a solid-rock bottom, it should be tested with a well drill or some other means to find its thickness. Samples of the supposedly solid rock should also be secured.

Another fact to be considered always is the drainage area. I do not believe we can tie ourselves to the drainage areas as they appear from an insufficient examination. The examination should be very thorough, and in addition to drainage areas, I think it is very important to take into consideration records of extremely high water from whatever cause (unless caused by artificial reasons, as a dam which has ceased to exist), and the design should be made accordingly.

In regard to width, I heartily agree with Mr. Older that 20 feet should be the minimum width for our modern structures. They should be certainly that width to allow two vehicles to pass safely. It is rather a short-sighted policy to consider a 16-foot bridge, especially of the high-truss type.

There is an urgent need, and has been for several years past, for some national or cooperative State legislation to decide on a definite limitation of the wheel or axle load to come upon our bridges. We design a pavement to carry a certain load, and if it becomes inadequate within 10 or 12 years or 15 years, we have nothing more to dread than a destruction of pavement and the pavement is of itself more or less temporary in nature. But when a concrete bridge structure is erected it should be, if we can make it so, sufficient certainly for our generation if not for all time. Therefore, if we are to design a highway bridge structure intelligently we must do it with some definite loading in view, or else our work will be of a very temporary nature and will be found inadequate by the next generation if not by our own.

NEW YORK'S 1920 PROGRAM.

State Highway Commissioner Green, of New York, has announced that plans have been made for the construction of 172 roads this year. They will have an aggregate mileage of 725.5, of which 527.26 will be constructed of reinforced concrete, in keeping with the policy to build only permanent roads, which will last from 25 to 50 years under the heaviest traffic and at a lower maintenance cost than lower types of roads. It is expected that all contracts for these roads will be let by the end of April in order to make it possible to complete the roads during the working season.

The Marking, Signing and Making Safe of a State Highway System.

LEVI H. NEILSEN, Deputy State Highway Commissioner of Michigan.

UNDER the legislation providing that the State trunk-line system previously established by law should be "improved, constructed, and maintained under the direction, supervision, and control of the State highway commissioner," he was also instructed to "cause all State trunk-line routes to be distinctly marked by signs and guideposts of a uniform design as may be deemed necessary for the public convenience and necessity," and "to cause to be published a map of the State of Michigan showing thereon the State and county road system." Provision was also made for numbering the routes and showing the corresponding numbers on the roads shown on the maps.

Following out the provisions of this legislation several designs were considered, with the result that a standard design was agreed upon consisting of a diamond 15 inches in length and 13½ inches wide. Across the middle will appear the words "State Trunk Line" with a block "M" above and the numbers of the route shown below. For the markers to be used on telephone and telegraph poles a black letter on a white background will be used. This will also apply to markers placed on buildings and suitable natural objects along the roadside.

For this preliminary marking stencils and county maps showing the roads to be numbered in each county have been prepared and instructions to the county authorities made ready to send out.

These markers will be placed on telegraph and telephone poles when they are available, on both sides of each intersecting cross-roads with an occasional one in between. Three to six hundred feet before a turn in the road is reached the white band will be widened and an "R" or "L," as the case may be, shown below the standard marker. Where a pole is not available and no buildings or natural object will answer the purpose cedar posts will be set up and the markers placed on them.

Standard railroad-crossing signs will be shown about 600 feet from all grade crossings. Dangerous curves will also be marked.

Although it is not the intention to maintain that portion of the routes lying within incorporated cities and villages previously paved, it is very necessary that it be plainly marked through every village and city. It is our intention to place direction signs at the intersection of the routes with improved roads showing distances to the nearest town.

MAPS AVAILABLE TO PUBLIC.

For the present no marking of the county road system is planned, although it is expected that a standard design for marking them will be decided upon within another year. The marking so far referred to is primarily intended for the guidance and information of the traveling public. In order to make this information most valuable, the map referred to must be provided and made available to the public. Because of the shape of the State, it was thought advisable to issue two separate folders, one showing the routes in the Upper Peninsula and the other those in the Lower Peninsula. This map is now being published and will be available for distribution by the time it will be possible to do the marking, which will be early next year.

In addition to this marking it is proposed to place mile markers on all the routes. Locations for these will be determined by automobile speedometer readings. These mile markers will consist of black diamond-shaped boards with a white molding border and the standard lettering in white. These will be set on angle-iron posts. The posts will be numbered from the south to the north and from the east to the west.

At the same time that the location of the posts is determined a variety of information can be gathered and compiled for future use.

DISCUSSION OF MR. NEILSEN'S PAPER.

Frank T. Sheets, engineer of design, Illinois: It might be interesting to the members of this association to know the system which has been adopted by the State of Illinois for marking the State bond-issue routes as constructed. We have adopted a concrete sign. The head of the post is 4 inches thick, 2 inches wide, and about 20 inches high. It is made of concrete, using a white cement. The outline of the State is grooved into the post, and the outline then is painted black. On the face of the post appears the number at the top, "24," indicating the number of the State bond-issue route as fixed by law. The red figure "142" indicates the location of this marker on the system, and this same number will appear on the State map, which we will ultimately complete, which will show the location of point 142 on the map. This 142 tells a dual story. It serves to locate the point in the field with reference to the map for the convenience of the tourists, and also indicates the approximate mileage from the eastern and northern terminals of the route. At the bottom appears the letter "L" or "R," which we all know is the conventional sign for turn to the right or left.

These posts have a total height of 8 feet, are embedded in the shoulder of the road adjacent to where the ditch breaks off, to the extent of 3 feet, so that the post stands 5 feet above the ground, just where the vision of the driver will naturally catch it, also where a headlight will pick it up at night. This we find is meeting with universal approval among the motorists of Illinois. I think we can not too fully emphasize the importance of properly marking the highway system when we build it.

We have been including these posts as one of the items in our contracts, but we think we are paying too much for them. The contractors have been bidding something like $20 a piece for them, so we have almost come to the conclusion that the proper thing to do is to let the contracts for the road and the markers separately.

WISCONSIN MARKER SYSTEM.

J. T. Donaghey, maintenance engineer, Wisconsin: It might be of interest to say a word about the Wisconsin marker. We have had the system marker now for two seasons and it has proved very satisfactory. Our main truck line system is marked, beginning with 10, and going as high as necessary. We number from east to west and from the south to the north. The plan was originally designed for the benefit of our construction men. But now we are going to give the public some benefit of the mile numbers. Our mileposts are flat, made of 3 by 6, and are painted with the number of the trunk highway. The first milepost has "1" on the south side and "2" on the north side of the post. The next one has "2" on the south side and "3" on the north. So you you know you are in mile 2 or mile 3, as the case may be. Everything is on that basis.

This year we are getting out a new map and are preparing an index that will tell the traveler exactly where he is at any moment. Turning to trunk highway No. 17, it would have an index that would give the mileage of every town on that highway. So he can tell by the number of the milepost exactly how far it is to any point he wants to go.

We have adopted and are using a very cheap method of marking the system. The marks are the same as Mr. Neilsen has described. We place them on the telephone poles at convenient places. We aim always to have a mark in sight on all trunk highways. At any point looking ahead you should be able to see a mark on a telephone post or posted on a culvert wall. The head walls of all culverts and bridges are painted white and the mark which we use is a triangle containing the trunk highway number. That mark is placed on the right head wall of the culvert. On the left is the number of the culvert.

WOOD USED ALMOST ENTIRELY.

We use wood entirely except for danger signs, which are enameled steel and not satisfactory. The wood signs are satisfactory. If we had it to do over again we would use wood for all purposes. They are set on cedar posts, which we can buy very cheap in Wisconsin. We find that we have to change quite a few posts, mileposts especially. We make a great many relocations. Sometimes we get away entirely from an old road, especially on what we call permanent roads. So we have to move a great many mileposts until the system is completed, and we believe wood is much cheaper than anything else; and until we finally develop the system to the point where we know we are going to leave it we don't believe we will place concrete marks and signposts.

The mile marks to be placed on the signs were determined by speedometer measurements. After the system was selected, as provided by the legislature, we made what we called a conditional survey of every mile on the system. We have in the office a chart from each county showing what was found at that time, the type and condition of the system. At the time we made those surveys we located the milepost and the speedometers were calibrated for correctness. We ran out a mile of steel tape and made our speedometers correspond with the actual measurements within a few feet. Many times we had to change the tires to get the speedometers to read correctly. We think it is very accurate as far as distance is concerned.

At the same time we located all signs. We had a black sign copy for the boys to use. A stake was set 2 feet back of the point where the engineers determined the mileposts should be placed. It was placed where automobile lights could reach it at night, not too far toward the outer edge of the right of way, and still, out of the way. The stake we placed carried the number of the trunk highway, and the number of the milepost. If it was a direction sign the stake carried the letter "D," the number of the sign, and the number of the trunk highway. The sign was painted from the information supplied on the sign copy, and the sign was erected by the county.

In marking through cities and villages we insisted upon having a mile mark on each side of all street intersections. That is, we have two mile marks as near as possible to the street intersections throughout the cities and villages. That is very essential. People get lost in the cities and villages easier than any other place. So we have adopted that plan of having two marks in every block. When you get near the intersection you know you are all right. The "R" or "L" shows you where to turn.

INTERSTATE COOPERATION.

All trails passing through our State must be marked to correspond to our marking system. Persons interested in marking such trails must follow our marking instead of theirs. So far, the marking of trails has done us more harm than good.

An excellent beginning has been made along the line of interstate cooperation in marking the through roads. I believe Minnesota has carried our No. 12 through Minnesota. Michigan has carried our No. 15 through the peninsula. Illinois is thinking of carrying our No. 10. I believe adjoining States that are intending to number their highways should take the matter up with the other States. Our highway No. 12 should start at Chicago. We ought to start our numbering at Chicago and pick up the distance at the border. Let Minnesota take up the distance at her border. The traveler would then know where he was all the way. If we can cooperate in that way we can work out a marking system that will benefit all the States.

Just another word in regard to detours. We mark detours plainly, with large white boards, showing the trunk highway number and an arrow pointing the direction of the detour at each end, and many times along the detour to show the traveler where to go. We also have paper detour signs which we nail on the telephone poles instead of painting on. In connection with that, we have the patrolman maintain the detour on his regular section.

EXPERIENCE IN MINNESOTA.

J. H. **Mullen**, chief engineer, Minnesota: We have had experience with painting trail signs, which at first was very unsatisfactory. Professional trail painters came into the State and would go to various villages and get them to contribute money, anywhere from $15 to $20, to paint blue, green, or red trails. The location of the trails depended on where the professional painter got the most contributions, and had no relation to the best road to travel, although they tried to follow, I suppose, the main lines of traffic.

The condition promised to become so bad that we had an act passed by the legislature making it a misdemeanor to paint signs on the public highway, except when approved by the highway department. So, now if it is desired to paint a trail through our State, permit has to be given by the highway department. There must be an incorporation of the organization that is going to paint the trail. They must give us a record of their organization, where the trail is to be painted, a complete map of it, and a drawing of their design. Then they are protected in that design.

For instance, take the Burlington way. They have an orange and white marking which runs all the way through the State and happens to be a good marking. They paint every telephone pole so that you see one continuous line of orange and white along that road. They filed that mark and no one else will be permitted to mark orange and white markings of the same form on a highway. They are obligated to keep that up, and it is a misdemeanor for any one to deface those signs or reroute the road.

We had some trouble at first. Perhaps a man with a garage two squares off the traffic would paint a sign to point his way. That sent the stranger out of his way and with the large body of tourist traffic in Minnesota it meant quite a lot.

RIGHT-OF-WAY MARKS.

W. S. **Keller**, state highway engineer, Alabama. This might be of interest to some of you, especially the southern engineers who have been troubled as we have with encroachments upon the right of way. We established right-of-way marks. We get 50 feet right of way, generally, for our roads and at the P. C. and P. T. and on long tangents, at intermediate points, erect simple little concrete right-of-way marks, placing them right on the border of the right of way. So far the contractors, generally, have bid from $2 to $2.10 apiece. The mark is about 5 feet in length, 8 by 8 inches at the bottom, and 6 by 6 at the top, approximately, with the letters "R. W." sunken into the upper part. It stands out of the ground about 2 feet. We believe that will preserve our right of way and future trouble will be avoided by it. We have had a great deal of trouble in the South for years past. Farmers have what we call snake fences. When they build the fence the center of it is on the line; but when they improve with a wire fence, they build the new fence before they tear down the rail fence and they are very particular to put the wire fence on the outside. So they are constantly taking the right of way. We believe this a very easy way to retain the right of way that we secure.

INTERSTATE NUMBERING SYSTEM.

M. W. **Torkelson**, bridge engineer, Wisconsin: I have often thought that we should have an interstate marking system with each State adopting the interstate number for through roads passing through the State. We would have a system then that would work nationally and locally. I think the members of this organization should get together and bring that about. A man could travel from New York to San Francisco following one number all the way, and as the trail passes through the State that number (say 21) would be the State's number for the road also.

If anything like this were attempted, I believe the interstate numbering system should carry for each State a color which could not be used in any other State, so that the traveller would know, by the change in the color of the markers, when he arrived at a State line.

Maps of State Highway Systems for the Use of the Public.

M. W. WATSON, State Highway Engineer of Kansas.

A MAP to be of real value must be prepared along definite lines to meet the needs of its user. Maps of State highway systems may be classified into several classes, but the two most common divisions are those for use of nontechnical persons and those for the use of engineers. The map that will prove the most beneficial to the greatest number of people is undoubtedly in the first of these classes.

To be of service to the general public a map must not be so designed as to confuse the ordinary user at first glance. Contours or other common engineering symbols are as Greek to the uninitiated. The most outstanding feature of these maps should be the main traveled through routes or State roads. Cities or villages must be shown to make the map of service, but they should not be so conspicuous as to make it appear that each place is the center of the universe, as is sometimes done on advertising maps.

Railroads should be shown, but so drawn and designated as to be more of a background than one of the primary features of the map.

Waterways are a necessity to make a map complete and any unusual feature, such as a ford or ferry, should be indicated. In mountainous country and in lake regions these topographic features are of considerable value to the traveler as a matter of location, and should be shown.

It is possible in some States to show on a State map all the public highways open for travel, but such an undertaking in one of our Central Western States where every section line is a road, with a few in between for good measure, would produce a map that is of no real value to the public, being similar in character to a Chinese puzzle.

It seems rather general practice to show the State or primary roads in heavy red lines, with the secondary roads shown by narrow red or black lines, and this method is especially desirable for contrast if the other features are in black, blue, or green.

ADVANCE IN ROAD MAPPING NEEDED.

Observation of the maps of the different States convinces me that no great advancement has been made in State road mapping to date. Some are in the blueprint state, while others are elaborately engraved. The scales and general design of the maps are as different as the number of States, so that a weary traveler crossing the State line, if guided in his path by published State maps, would be obliged to rest for a while in some shady spot to familiarize himself with the details. This may be an advantage in some cases, but it most certainly would be a disadvantage if one is trying to make a certain place in a short time.

M. W. WATSON.

One fact, however, which stands out, is that practically all of the States have laid out a system of highways and are working toward their completion, and the great majority connect with each other at State lines so that with the completion of these State systems of highways a national system will be secured, and it will be located to serve the best interests of the States and their people much better, we believe, than would be the case were the system laid out by a national commission unfamiliar with the conditions in each locality.

The maps of the United States Geological Survey are available for detailed information where they have been completed, but a number of States are not so fortunate as to have these maps for the entire State. Coast and Geodetic maps are also of service, especially in States bordering on the lakes or on the seacoast.

PROGRESS AND SPECIAL MAPS.

For the purpose of showing graphically the progress in constructing State road systems, it is usually advisable to have a progress map so drawn as to indicate the roads under construction, roads partially completed, and roads completed on the State system.

This map should first be drawn showing the State roads with a double line, so that as the work progresses these lines can be filled in, either by different colors or with a progressive system of symbols.

A number of special maps are of use in the work of a highway department. For the purpose of explaining State bond issue elections to the people, skeleton maps showing straight-line connections between principal points are adequate when combined with maps showing graphically the area, population, and valuation affected.

FRENCH ROAD MAPS.

The French maps, which were highly praised by service men, are a very complete system of highway maps with every detail shown. The country is divided into sections so as to permit of a larger scale than would be possible if the entire country were drawn in one map, and by referring to a key map on the back of each section they can be very easily combined. A feature of special value to the traveler which is shown on the French map, but which we have not found on any of our American highway maps, is the showing by symbols of all ascents and descents, special reference being given to dangerous descents.

A uniformity of maps should be worked out so that some standard scale and design would prevail throughout the country. It might be advisable that some of the governmental mapping departments handle the preparation and completion of the State road maps throughout the Union so as to have uniformity. The writer suggests that a committee of this organization be appointed to formulate a definite plan for uniform maps and to report at the next session.

DISCUSSION OF MR. WATSON'S PAPER.

Thos. H. MacDonald, Chief of Bureau of Public Roads: Along the lines of this paper, I would like to say that all the map-making agencies of the Federal Government were recently called into conference by the Secretary of War and the Chief of Engineers of the Army, and certain general policies were formulated to correlate the work of the several agencies and hasten the completion of the Geological Survey sheets.

Their recommendations looking to the completion of these sheets are now before the President. The principles upon which the report is based are, first, that the Coast and Geodetic Survey shall be held responsible for the primary control lines; second, the Geological Survey shall complete the topographical sheets in accordance with their present standards; third, that all other map-making agencies of the Government shall do their work in such a way that the information required to fill in the standard topographical sheets of the Geological Survey will be secured and will conform to the controls established.

The Bureau of Public Roads has up with the Geological Survey now the proposition of getting up standard road maps on the basis of the maps of the Geological Survey, particularly for those States that now have no maps. We hope to carry that forward so that at least we shall have working maps on which to lay out and classify the roads in an orderly manner, and trust that they will give a national aspect to the proposition of road classification.

The Alignment, Grade, Width, and Thickness in Design of Road Surfaces.

CHAS. M. UPHAM, Chief Engineer, Delaware State Highway Department.

IN THE consideration of practices influencing the design of modern road surfaces, with especial reference to alignment, grade, width, and thickness, this paper will deal with generalities, and will not consider specific cases, for it is evident that it would be impossible to recommend any definite method or practice, within narrow limitations, at least, that would satisfy all conditions, as they vary throughout the entire country.

When the problem of the design of highways is taken into consideration, there are several rules that can be followed and accepted as the best practice. These rules are the result of years of experiment and trial and if followed will assure ideal results and conditions, but in every locality there will be varying conditions and local influences which will make it impossible to follow consistently these fundamental rules of road design.

Almost the first step in the design of a highway is the study of its location, keeping in mind the purpose which the particular highway is to serve. If the highway is constructed as a scenic road, then the problem is well defined, but if the highway is to serve as a lane for commercial or industrial traffic, the problem becomes more complicated and careful study is necessary in considering the question of how local traffic can best be served without lengthening the distance and introducing curvature. At the same time the question of grade must be considered in connection with the alignment. The ruling and intermediate grades kept within an economic per cent, the total cost of grading should also be considered.

The location of a road resolves itself into a problem of economic compromise, depending on the solution of these factors.

THE GENERAL PROBLEM OF DESIGN.

There are few localities where ideal alignment and grades can be secured, and though, in most places local conditions and limited topography make it impossible to attempt this ideal alignment, still the inclination to lean towards the ideal alignment should always exist, though it be impossible to attain completely.

There are more variables affecting the problem of width of roadway than in the choice of alignment and grade. The width of highways should be dependent upon the alignment and grade, as well as upon the amount and character of traffic and the character of the roadside.

In considering the thickness of the pavement, there are several features that must be taken into consideration before a final decision can be made. With unlimited funds it would be a simple problem to select a thickness of pavement that would carry all traffic, but the problem is to design the economic thickness—a pavement that will carry the load without any surplus thickness beyond a reasonable factor of safety. Of course, the thickness of a given type of pavement is dependent upon the character, number, and weight of the vehicles that it must carry, as well as the character of the soil in the subgrade, and the possibility of completely and quickly draining it.

In order to keep the consideration of the above subject general, and in order to form a nucleus about which recommendations and practice could be discussed, I wrote to several State highway departments, located in different sections of the country, and asked their practice in the design of roads with reference to line, grade, and thickness. The replies show that on alignment and grade, most of the States were traveling in the same general direction, some approaching nearer than others to the ideal condition. When the question of widths was taken into consideration, it was noticed that in those States, in which were located the largest number of cities, and where traffic had become excessive and the demands for more room had been felt, wide pavements were being constructed.

A uniform thickness of pavements seems to have been followed by all the States, with the exception of those in which were located cantonments. In these particular cases, a greater thickness of pavement has been adopted.

ALIGNMENT.

In giving consideration to alignment roads may be divided into two classes, roads located within parks, and intended as scenic roads and used mainly by sightseers and tourists, and roads that can be considered as commercial or industrial roads, which would be located within and between business centers, towns, and cities.

In the alignment of the park or scenic roads, it is not essential to have long tangents nor direct routes; the only essential requirements of these roads are that they shall furnish lanes of travel for pleasure riders, and shall be properly designed and constructed from the standpoint of safety and beauty. These roads need not be laid off in direct routes, because speed or time is not generally an element to the users of these highways.

The controlling points of the scenic road are beautiful views, magnificant trees, costly residences, and in fact, any detail that may serve the purpose of making the road more beautiful. With the controlling points fixed, the only other consideration is that of safety and the expense of construction.

There seems to be a practice in practically all the States, that, from the standpoint of safety, the alignment of the scenic roads should be such that the radius of all curves should not be less than 300 feet, though in many instances it is common practice to use radii of 200 feet or less.

The commercial road may be described as that road which will most economically serve the commercial or industrial requirements or, defined in another way, may be called the direct route.

In considering the alignment of commercial roads, or direct routes, it must always be remembered that a straight line is the shortest distance between two points, and from a commercial standpoint the shortest way is not only the most direct, but with other things equal, is the most economical; therefore, it seems to be practically conceded that ideally aligned commercial roads are those that are laid in absolutely straight lines.

Where there are costly influences entering the problem that make it impossible or impracticable to follow the straight line, then the alignment should approach the straight line, and become a compromise of line, grade, and cost of construction.

The straight-line method does not require that only two distinct points should be given ultimate consideration, but each and every community and business district lying between these points should be given due regard, and the line should run in the most direct line possible connecting these intermediate controlling points, provided the line will form a direct route.

More stress has been laid upon the alignment of roads during the past two or three years than ever before. It simply shows that highways are passing through the same stage that the railroads passed through when, after exhaustive studies from an economic standpoint, they spent considerable money for the straightening of their lines. The problem of the highway is practically identical with that of the railroad. Much study should be given to final location, for, after all, the location of a road is the only permanent detail; therefore, this should approach the ideal as closely as possible.

In the construction of hard surfaced roads, the alignment is well defined, and a very small change in direction or a slight angle can be plainly seen. If breaks in the line are necessary they should be located on the tops of hills or summits in the grade.

If necessary to use a curve, then the flatter the curve, the safer the road, and this would not jeopardize the beauty or purpose of the road in any way. When a curve sharper than 4°, or of 1,433 feet radius, is used, the roadway should be elevated on the outer side and widened on the inner side. This will overcome the tendency of the traffic to skid and make driving both safer and more pleasant.

FACTORS TO BE CONSIDERED.

A very important feature in deciding the alignment of roads, is the consideration of the through traffic. The ideal road is one that will serve through traffic by direct routes and also make it possible that this traffic need not be delayed on account of congested districts. In other words, the best alignment for a through-traffic road, is a straight line so located as to pass near, but not pass directly through these congested districts. With such a location the through traffic is not subjected to interference or delay which is always present in the main thoroughfares of towns and villages, nor on the other hand is the town or congested district subjected to the hazard of the through traffic. By such a location the congested districts have all the benefits of a modern highway, but are not subjected to its disadvantages. Therefore, when considering alignment, this is a very important factor to keep in mind.

Under alignment, there may also be mentioned the subject of the width of right of way. This we find in nearly every State has been neglected or it has given considerable trouble, when road developments have been carried on in a modern way. Until recently only in a few States were rights of way obtained wider than 40 feet, or was there any effort made for direct routes or straight lines.

With the roadway sufficiently wide to take the amount of traffic and to provide such space as is generally necessary for shoulders and drainage, a minimum right of way of 60 feet should be obtained in districts outside of cities and towns, especially if the country is at all rolling.

When the smaller towns are approached or entered, a right of way of sufficient width to allow for the widening of the roadway to carry the additional traffic should be obtained, as well as sufficient width to carry into effect any beautification scheme, such as grass plots, flower gardens, and tree planting that may be developed at any time in the future.

In the case of cities, it is advisable in the construction of any road to secure, as soon as possible, sufficient width of right of way to provide for future development, such as might include wide sidewalks, grass plots, areas for tree planting, besides sufficient roadway to take care of the ultimate traffic.

It may possibly be said that through many villages and small cities it would not be practical to secure such width of right of way as recommended, especially after developments in property have been made. This might be true if it were necessary to bring around this condition immediately, but this could be provided for ultimately by establishing new building lines or property lines, making it compulsory that all future development and rebuilding should be a certain distance from the road. In this way a wider right of way would finally result, without the expense of an immediate change.

GRADES.

It may be said that a highway, as a factor in transportation, is no more economic or efficient than its ruling grade. Grades and alignment seem to be so closely related, that many times one is dependent on the other, or one is bettered at the expense of the other. In any case the ideal conditions should always be kept in mind, and any compromise should conform as closely as possible to the ideal result.

The same general division can be made with regard to the choice of grade as to line, namely, scenic roads and commercial roads. On the scenic roads safety and beauty seem to be the controlling factors, while on commercial roads the problem is an economic one, and the requirement is that the road be usable at an economic minimum of cost or effort.

In designing the grades for highways there seems to be a general tendency for the States to make an effort to limit the maximum or ruling grade to 6 per cent, with the possible exception of short stretches, which seem to be allowed in most States. This 6 per cent grade was established in the days of horse-drawn vehicles, and while it has served for that purpose it has not been definitely established that it is the most economic grade for motor vehicles. A maximum or ruling grade for motor vehicles is the steepest grade that can be negotiated with minimum of power. This problem is now being studied, but it can only be determined after careful study and experiment and close cooperation with the motor industry.

In most States it is impracticable and almost impossible to hold to a grade as low as 6 per cent, and in these cases, if a grade considerably in excess of 6 per cent seems necessary, a study of relocation should be thoroughly made with an end in view of reducing the grade. It is economic to increase the length of line if a reduction of grade will result.

At the beginning and end of all grades, vertical curves should be used in order that the grades shall preserve a continuity and can be approached gradually, as well as provide a long line of vision. There is one definite conclusion, however, that we can draw relative to grade—the power required to surmount the grade increases proportionately to the per cent of grade. With this law established, we can see that the level grade would be the ideal grade from an economic standpoint. With this definite law, the problem of grade is somewhat simplified and can be determined. In many cases more power is absorbed in overcoming the surface resistance than in overcoming the grade.

It was often thought that before a grade or hill was improved it was the grade that was causing the resistance, when as a matter of fact the road surface probably caused many times more resistance than the grade. With an unimproved surface the grade resistance is a small percentage of the whole resistance; with an improved road the grade resistance forms a much larger percentage of the whole, showing the necessity and economy of reducing grades, if we wish to retain the advantage when hard surfaces are constructed.

After establishing the level grade as the ideal economic grade, all efforts should be made to approach this grade in the design, and any compromise with line or expense of construction should be made with the ideal grade in mind.

WIDTHS.

While the requirements of width of pavement can be divided into demands for scenic widths and commercial-road widths, the demands and requirements are so closely associated that only commercial roads need be considered.

While the width of pavement can be said to depend almost wholly upon the character and amount of traffic, the problem still remains far from being solved on account of its being affected by the variable known as the personal equation, a variable to which it is impossible to assign exact values.

The worst condition exists when wide trucks are placed side by side. The average width of the wide truck is 8 feet; two trucks, therefore, would require, theoretically, the entire width of a 16-foot road. Practically, however, due to the overhang over the wheels, these trucks might be placed on the pavement so there would be a 2-foot clearance between the bodies, provided each truck went to the extreme edge of the pavement in passing. This, however, is not often the case, due to the fear of getting too close to the edge of the roadway, and the uncertain condition of the shoulder. For this reason it can readily be seen why most States have already relegated to history the 16-foot roadway, and adopted 18 or 20 feet for the width of a double-track road.

For a two-track roadway nearly all States are now advocating 18 feet with a minimum of 3 feet of shoulder on each side. A few of the States still adhere to a roadway of 16 feet, but in this case, shoulders are always provided which the traffic may readily use if it is necessary.

For a road of three traffic lanes many States adhere to 24 feet in width, but there seems to be a growing opinion that this should be increased to 26 or even 30 feet.

The reports of the American Road Builders' Association, covering this subject of widths, recommend that double-traffic trunk highways should be at least 20 feet wide with a minimum width of shoulder of 5 feet. Nine feet should be added to the width of the roadway for each additional line of traffic. Wherever the right of way can be acquired, provision shall be made for shoulders of at least 9 feet in every case. This is for the purpose of future widening of the roadway when necessary.

LAWS OF TRAFFIC.

To widen the roadway to certain limits is a step in the ideal direction, but it can not be said that a roadway should be widened without limit, for after a certain width is reached and traffic becomes heavy, the width may be more intensively used by establishing separate lanes for the fast and slow traffic.

The cost of the road enters strongly into the determination of width, and when the compromise is made the minimum should be sufficiently wide to take care of the lines of ordinary traffic, plus as much clearance width as the importance of the road and the intensity of the traffic justifies.

Regardless of width of roadway, the shoulders should be maintained in a serviceable condition for cases of emergency. If the roadway is not sufficiently wide to provide for traffic, the shoulder will receive considerable of this traffic and cause excessive maintenance. Many times, this excessive maintenance would pay the cost of construction of wider roadway, which would result in a much lower shoulder maintenance and provide a more satisfactory pavement.

In level countries where alignment is straight and curves are flat, there seems to be no necessity for an increase in width from the general widths required for the various numbers of lines of traffic, but in countries where the alignment is not straight, it is quite essential that the width on all curves of 10° and over should be materially increased.

The increased width should be added on the inside of the curve and begin at a point ahead of the point of curvature and extend beyond the point of tangency. The additional width required varies according to the degree of curve and local conditions.

Many States after deciding upon their unit of width have made their width of road entirely dependent upon the amount of traffic. Where there is a traffic of from 3,000 to 4,000 vehicles a day, the roadway is made not less than 18 feet in width; where the traffic includes 5,000 vehicles and more during the day, the roadway is made at least 26 feet and sometimes 28 or 30 feet. Satisfactory shoulders should be provided, to carry the traffic which may be forced off the metal roadway onto the shoulders.

Some States have decided that if a hard-surfaced pavement is to be used, the minimum roadway, in order to provide for a single line of traffic, should be at least 9 feet in width and preferably 10 feet. A pavement of this kind should not be attempted unless there are satisfactory shoulders of sufficient width and character to enable vehicles to pass without danger, or unless turnouts are provided at intervals.

THICKNESS.

To make any specific recommendation as to the necessary thickness of the pavement would be attempting to solve a problem wherein there are two or more variables, for the thickness of a pavement not only depends upon the demand of traffic that the pavement may be subjected to, but also depends upon the type of pavement and the conditions of the subgrade and drainage system, which influence not only the strength of the pavement, but its resistance to withstand the numerous and varying loads. Practically all failures of the old pavements that were designed to withstand merely the demands of the lighter vehicles, were due to the wear of the surface. As the loads upon these pavement were increased, the pavements broke down under the overload, and were thus prevented from wearing out in the old way. This would seem to indicate that a pavement possessing the quality of tensile strength which will enable it to act as a beam is demanded.

Pavements are called upon to withstand compressive stresses, to resist tensile stress, set up, when the pavement is subjected to beam action, and to resist shearing stresses. It seems that most of our pavements have been so designed as to withstand the compressive and shear action, but the greatest trouble has been found in attempting to design a pavement that will withstand stresses when the loads bring about beam conditions., Of course it will be a simple matter to design a pavement that will act as a beam and withstand any load, provided it is not necessary to keep in mind the necessity of keeping the cost within moderate limits. In order to limit the necessary thickness of pavement to a minimum, considerable effort has been made in the way of distributing the weights or forces over a large area.

Other experiments have been made using a cushion to overcome impact.

SUBGRADE CONTROLS THICKNESS.

Almost the first step in designing a pavement must be to assume the nature and condition of the subgrade; the better the subgrade, the thinner it is possible to make the pavement.

As the conditions of the subgrade become worse, the thickness of the pavement must be increased, so that on account of the changing conditions of the subgrade our first assumption is full of variables. Generally the design is not changed for each condition of subgrade, but the worst place is considered and the entire pavement designed from these conditions; this, of course, is uneconomical.

The ideal limit would be to have a perfect subgrade so that only a thin road surface would be required. As the subgrade becomes worse in character, the thickness of the road surface must be increased for the purpose of distributing the loads over a wider area. A popular method of load distribution has been the use of a rigid base such as concrete.

While in many designs it is assumed that the stresses travel from the load to the subgrade along lines inclined at angles of 45° to the surface, actual experiments show that in a concrete surface, the lines of stress reach as far as 6 feet from the point of load application; this means that the load is sometimes distributed over a 12-foot area.

Now the problem is to design the road to take care of compression, punching shear, and beam action. Taking into account the distribution of stresses produced by the load, either a concrete pavement, or a pavement with a concrete base, surfaced with bituminous material, will provide the necessary compressive strength, and the minimum of design, supported by a satisfactory subgrade, has always been ample to provide for punching shear, as our problem seems to be the design of a surface that can withstand the tensile stresses which are developed when the road acts as a beam. Designing on this basis, we find ourselves at a loss for assumptions. The span can hardly be assumed to be identical with the total limits of the load distribution; generally the span would be much shorter. But even if the span were considerably shorter, the designing of this pavement as a beam would be almost prohibitive in cost.

It has been computed that in a pavement designed as a beam to withstand a 20-ton truck, the reinforcement would cost between $2 and $3 per square yard. This of course is prohibitive, and even if we assume the best subgrade conditions to exist, our reinforcement would cost about $1 per square yard, and then we would not be taking care of our worst conditions.

BETTERMENT OF SUBGRADE.

It therefore remains for us to look about for ways of designing the thickness of pavement other than by greater thickness of substances like concrete or by the use of heavy reinforcement.

About the only other place to look for a betterment is in the subgrade. We can see that if the subgrade is perfect, only a very thin surface will be necessary and it is only when the subgrade is weak that a thicker surface becomes necessary. Is there not some way, then, in which we can improve our subgrade and thus avoid the necessity of increasing the thickness of the pavement surface?

At the present time, we artificially drain our subgrade to a limited extent. Further draining would assist toward bettering the subgrade. To complete this operation and bring the subgrade to a nearly perfect condition, the use of a layer of crushed stone 2 or 3 inches in thickness spread over the subgrade and connected to all the drains, is recommended. Such an expedient would improve the firmness of the subgrade, and if the thickness of pavement surface is dependent on the character of the subgrade, the thickness of the surface would be thereby reduced considerably. It would seem that an economic pavement would be one of a material such as concrete laid on a carefully prepared subgrade, designed as previously described. If it be desired to absorb the shock of excessive impact such a pavement could be covered with a bituminous surface. This would mean a bituminous mat that would absorb impact and transfer the loading to the concrete, which in turn would distribute the load over the prepared subgrade When the subgrade is prepared as described, there will be slight chance of its shifting, which would mean that the span between supports will be small, and will further mean that a much thinner concrete distributing layer can be used.

In order to crystallize the points of this paper on line, grade, width, and thickness, the following conclusions may be drawn:

Alignment.—On scenic roads the straight line is not absolutely necessary but careful attention should be paid to safety. On commercial roads the straight line is ideal and all roads should approach this alignment.

Grades.—While the grades on scenic roads should be held low wherever possible, the ideal grade on a commercial road is the level grade. Whenever a road surface is changed from earth or macadam to hard surface, the grade should be materially reduced if it is desired to retain the advantage of a hard surface.

Width.—The minimum width of a two-way traffic road should be at least 18 feet, an additional width of 9 feet should be added for each line of traffic, and suitable shoulders should be provided in all cases. After four or five lines of traffic have been thus accommodated the width should not be increased, but instead lanes for the separate lines of traffic should be constructed. All curves sharper than 10° should be widened and banked.

Thickness.—While thickness is dependent on the type of pavement and the nature of traffic, it is also closely identified with the condition of the subgrade. Bettering the subgrade affords the means of reducing thickness of pavement, which seems to indicate it might be more economical to spend money preparing subgrade than to attempt to support the loads by blindly increasing thickness.

DISCUSSION OF MR. UPHAM'S PAPER.

F. R. **Rogers**, State highway commissioner of Michigan: We can not go back of the elementary principles discussed in Mr. Upham's paper. I am going to confess a few mistakes we have made in Michigan, with some suggestions as to what we are thinking about doing to remedy those mistakes.

As you all know, one of the counties in Michigan has become quite famous for its concrete roads. We began by building concrete roads 16 feet in width, 6 inches thick. We have discovered they are not wide enough. We have had to add bituminous shoulders on the side. There is not any doubt in my mind but the shoulder upkeep on those narrow roads has cost enough since they were built to have widened them at least 2 feet on each side; so, had we looked ahead as far perhaps as we should, we would have built wider roads.

In Michigan, on the more important roads which we are paving, we are building at least 18 feet wide, and in some rare cases 20 feet. There is one in Detroit County that is 24 feet wide. That has been criticised by some engineers. Perhaps it was a mistake to build 24 feet. It perhaps was not much improvement over the 20-foot road. That road is asphaltic concrete of the Topeka type, with binder course, the base is 7 inches thick, the binder 1½ inches, and the concrete top 1½ inches. We rather think it will hold the traffic, because it was laid on an old base that was formerly gravel, into which some crushed stone had been injected. It was thoroughly scarified and widened, and there has not been much disturbance of the base.

I have in mind roads that have been built on sandy soils, one in particular on what was probably the ancient shore of Lake Huron. That road is only 6 inches thick and has not broken off at the joints, which practically substantiates, I think, what Mr. Upham has said about preparing a first-class base if we expect the roads to stand up.

We built two years ago, or a year ago this last summer, under war conditions, about 10 miles of concrete in Monroe County over a soil that does not lie so very high above Lake Erie, a clayey loamy soil, in fact, the worst kind of clay I know of. There are quite large side ditches, yet that road has constantly broken through under traffic. I am not quite positive, but I think the minimum thickness is 7 inches, with 8 inches in the center. And frequently when it begins to give, apparently pumping the water from the subsoil below (I do not remember the side drainage) we find a puddle under the surface failure. I am inclined to think that the treatment suggested by Mr. Upham of a subbase of macadam connectedwith a side drain, might have overcome that. We did find, however, that a piece of that road that was started on a subgrade prepared the year before, failed very much less than that constructed on the new subgrade.

So far as we are concerned, wherever we expect to pave, if there is much disturbance of the subgrade, or much cutting or filling, we are trying to do that work one year in advance of the paving, notwithstanding it makes it necessary to let a contract for cutting and drainage structures and later a contract for paving. I heartily agree with what Mr. Upham said about widths. We are a little bit at sea as to when we ought to build wider than 18 feet.

Mr. Fletcher told me an interesting thing that I have sometimes thought of to prevent breaking at the edges and particularly breaking at each side of the expansion joint on the edges. The elimination of the expansion joints will probably do away with that, but Mr. Fletcher says he is putting a ⅝-inch rod about 2 inches from the edge in the center of the slab which will reinforce and perhaps prevent breaking off. I asked him whether it was in the bottom or top and he said, "We don't know which way the stress is going to be, so we are putting it in the middle."

I think, in many cases, we build, not with a factor of safety, but with a factor of ignorance. I think there are a whole lot of things about road building that we do not know, and I do not think I can add anything to the knowledge that has been given.

ENGINEERS MUST DO IT.

James Allen, highway commissioner, Washington: A location may be dear at $75 or $100, and you may be merely wasting money; while on the other hand it may be economical at $400 a mile. You can not say a location should cost $100 a mile; you can not say it should cost $400.

I heard Mr. P. J. Pogue say once, "The most important work, as I see it to-day, for engineers starting on this great program of highway building, is for the engineers to do it." That is what I think. If the engineers are not capable of doing it, God knows the lawyers and doctors and bankers are not.

The alignment comes first and is most important. In heavy mountainous country you can not get perfect alignment. Do not pay any attention to the right of way; you will find all your right-of-way troubles come right at first. I venture to say that 75 to 90 per cent of our right-of-way troubles were never reported; they were compromised. In the State of Washington we have never yet had a jury award more damage for a right of way than our right-of-way agent offered the man; and in a lawsuit they don't get half or a third of what was offered.

Every highway out in Washington must be hard-surfaced. We can not get away from it. Gravel roads and other cheap types of roads are out of it. The alignment must be made right, as nearly right as possible. That is most important. I do not see how you are going to lay down any hard and fast rule for plans and specifications. You must study your road.

Mr. MacDonald: I am glad that Mr. Allen has spoken out in meeting and put the responsibility for the kind of roads we build squarely up to the engineers. In the past we have had to occupy a more or less apologetic attitude toward the public because we wanted them to go down into their pockets and put up a considerable amount of money for us to spend. We have that money now and we do not want to lose sight of the fact for one instant that the public is going to place the responsibility upon us for the kind of roads that are built. It may be that we may have considerable pressure brought to bear upon us from the doctors and lawyers and even from our commissioners, but with all due respect to these gentlemen, the engineering features are for engineers. It is a fortunate engineer who has a commission composed of business men, or lawyers, or doctors, or any other class of men, who recognize that they have engineers employed to advise them, who hold the engineers responsible for the engineering work, and follow their advice.

I do not believe that Mr. Allen accented too strongly the point that when it comes to the building of the roads and the choosing of the type of roads to build the highway engineers that are in this room are going to be held accountable. You can not pass the responsibility on to your commission or to the public. The engineers now in this room are going to be held accountable for the spending of the money that has been appropriated.

KANSAS ROAD LAWS UPHELD.

In a decision delivered January 20 the supreme court of Kansas by a unanimous vote declared that all the road and bridge laws of Kansas were constitutional and valid. The decision places the road program of the State on a sound basis, shutting off much opposition and many suits being planned by those against road improvement under the laws passed in 1917 and 1919.

Highway Administration.

GEORGE H. BILES, Assistant Highway Commissioner of Pennsylvania.

HIGHWAY administration, in the several States, is for the most part in charge of commissions, appointed by the several governors, who select their assistants, with their varying responsibilities, or a single commissioner, selected by the governor, with his deputies, chief engineer, and other assistants.

Either form if composed of men endowed with vision, imagination, and force, given to a determination to administer impartially and efficiently, all other things being equal, will succeed. Starting out, as many of us are to-day, with the responsibility for the expenditure of millions of dollars of public money, let us not lose perspective but work on a broad comprehensive scale, planning for the greatest good to the greatest number. Three contributing factors to this end are control, confidence, and courage.

Control, in the strictest sense of the word, should be exercised by centralized executive authority. The execution of our plans with intelligence, fairness, and dispatch will win public confidence, without which we will fail. The utmost courage to do the right thing in spite of the selfish aims and importunities of individuals or communities is required in the disbursement of public money.

GEORGE H. BILES.

CONFERENCE AND COOPERATION.

I am a firm believer in the wisdom of doing things through conference with our business associates and with the counsel of others. Many organizations depriving themselves of such counsel become affected with individualism, which usually begins at the top and results in a contraction or narrowing of the whole organization. This creature, obsessed with the idea of its own importance and sensitive to its prerogatives, ignores and resents the counsel of leaders of men and thought until too late, when it is enveloped.

One of the basic principles in the creation of an organization is to obtain zealous and efficient men, responsive at all times to the demands of the situation and working as a team for the realization of the aims and purposes of the executive. Recognition for meritorious service must be given such men, which is possible, only, when salaries are not fixed by statute. Men, under such stress, either go up or out, they can not stop or go stale.

In developing an organization of this kind it is our theory that the State organization should have power to supervise expenditures and operations and extend engineering and advisory assistance to the counties, townships, and towns, to prevent abortions, which are bound to result where innumerable engineers are permitted to operate promiscuously. If there is one thing that will jeopardize the consumation of a road program it is poor work, which may result from bad engineering or careless inspection. The inspector is the most important individual on the work for upon him depends the success or failure of carrying out the engineer's plans. The inspection force should be composed of fair-minded, intelligent, and practical men, holding allegiance to no one save their superiors, and should be paid a wage commensurate with the importance of the work.

The cooperation of the State creates a sense of security on the part of communities expending large sums of money and is the biggest factor in the success of good-roads campaigns throughout the State. Through such cooperation the comprehensive idea of main primary roads can be extended to the counties on secondary systems, with the ultimate satisfaction of seeing roads built to meet the demands of traffic, and creating a network of uniformly good highways.

Attract to your work strong contracting concerns with ample capital and equipment resource to insure completion of your program. Before work is awarded the contractor's responsibility should be established through presentation of his financial statements and assurances from banking institutions indicating their willingness to extend him assistance, if need be, to finance the project, accompanied by records of his previous performance in contract work.

A new philosophy can be preached to contractors in this era with surprising and gratifying results. If you can convince men of your fairness and sincerity of purpose, the great majority will be receptive to the suggestion that they must derive some compensation out of satisfaction in doing good work. Upon the award of contract the contractor automatically enlists in the cause, becoming as much a part of the organization as any of its employees, the only difference being that he is paid in units of work while the employee is paid in units of time.

MUST HAVE AMPLE POWER.

Prudence demands the passage of laws giving ample power to the organization to prosecute a program, when deemed expedient, with the departments' agents or employees, permitting the acquisition of property and construction of building necessary for the manufacture of any road material entering into the building of a modern highway, which materials may, in the discretion of the department, be furnished to contractors engaged in State road work.

In the administration of highway work on the scale upon which most of our States are launching programs at this time the greatest single requirement is organization and system. If we stop and think of the work units involved in the disbursement of $1,000,000 for this class of work and multiply this by 40 or 50 or more, as some of us must do, it will be apparent at once that it becomes an undertaking for big business organization and management.

In the first analysis, the duties of the several units of the organization should be grouped on a functional basis, the segregation of the special or distinct functions automatically creating the several separate divisions. Authority should be centralized in the executive head, between whom and the several operating divisions there should be a coordinating branch or body, known as the management division, in charge of an executive manager.

DIVISIONS OF ORGANIZATION.

A brief description will be given of the organization and functions of the major divisions of a modern highway department.

Executive Division.—The function of this division should embrace the determination of all policies not entering into the details of operation, for which division heads should be held accountable. As an assistance in the determination of policies the executive division should be supported by a strong organization equipped to devise means for the enforcement of its policies, and the coordination of the activities of the department. This responsibility logically is that of a management division, which may be termed the operating branch of the executive division.

Management Division.—The functions of this division may be briefly stated as follows: To supervise and place in force the principles of management as applied to all branches of the department; to determine the various operations of the department in accordance with the requirements of the statutes; to group the operations upon a divisional basis for assignment to the proper division and for the creation of the necessary organization therefor, followed by complete instructions; to schedule the performance of all phases of the department's work and disseminate the same graphically and uniformly and to follow up the various schedules presented, investigating all complaints and delays; to be represented at each department conference on investigation and research and to supervise the compilation of its findings, from which standard methods of operation can be devised for all phases of the department's work; to supervise the publication of all bulletins and periodicals upon the work of the department and to present to the executive body and general public the accomplishments of the department at convenient intervals; to supervise the development of future operations; to have control over the system and methods of procedure in all divisions, also office equipment and supplies; to provide for complete records of the personnel of the department and to supervise the work of all subdivisions which involve other subdivisions, whose work is general in its nature. Other responsibilities of this division include the authorization of funds, the compilation of statistics and graphic presentation of them.

Purchasing Bureau.—Some of the important questions handled by this bureau are the location of materials, grade of supplies, quantities available, shipping conditions, traffic regulations, local conditions affecting prices and storage facilities.

Contract Bureau.—A large construction or maintenance program involves the preparation of contracts and agreements which should be handled by a branch of the organization especially equipped with legal knowledge.

Equipment Bureau.—Systematic inspection with uniform instruction and standard workmanlike repairs to equipment requires an organization of mechanics and inspectors under a competent mechanical engineer.

Information Bureau.—The dissemination of information should be in charge of a special bureau in order that the best regulations may be established with the agencies involved, and also that there may be a uniform, and at the same time official, presentation of all information given to the public.

Stenographic, Typing, and Duplicating Bureau.—To provide uniformity and equalization of work, stenographic, typing, and duplicating work should be centralized in one bureau.

Filing and Mailing Bureau.—Uniform filing and mailing methods requires the handling of work of this kind in one bureau.

Construction Division.—The functions of the construction division at headquarters can be grouped upon practically the same basis as the department as a whole with the division of responsibility in accord with such grouping. These groups may be designated as engineering, drafting, and testing. The engineering branch, through its field offices should handle the making of surveys for all road and bridge construction work, also for change of alignment or other special work, as well as the supervision and inspection of construction methods. The drafting branch is concerned with the preparation of plans, the design of structures, and the handling of estimates. The testing branch should handle the checking and testing of materials entering into the construction of projects, together with investigation and research work to establish other sources of material supply.

Maintenance Division.—The maintenance division is concerned with the protection, through adequate maintenance, of the investment which has been made for road construction. Thorough instruction of employees, adequate inspection, the preparation of estimates, the authorization of work, the selection of materials and supplies, the shipping and delivering of the same, the securing and distributing of equipment and its operation, and the employment and payment of labor are duties incident to the carrying out of a large maintenance program.

Township Division.—This division of a highway organization is of unquestioned value in the service which can be rendered to townships through the assistance offered in the form of engineering advice and supervisory control of road building and maintenance. The approval of contracts for the expenditure of township funds, the enforcement of legislation applicable to townships, the distribution of reward funds, and the issuing of permits for the placing of substructures, telephone or telegraph poles and temporary crossings, is placed under its charge.

Automobile Registration Division.—The functions of a division for the registration of motor vehicles may be grouped as follows: Receiving, registration, filing, shipping, mailing, and inspection. Among the many operations in handling work of this volume are the sorting, classifying, and examining of mail and receipts and the auditing of accounts. The actual registration requires the typing and proof reading of certificates and the duplicating of ledger sheets and file cards. The filing of copies of the registration certificates alphabetically according to the registrant, and numerically according to manufacturers, and engine numbers are of material assistance in the recovery of stolen vehicles and the apprehension of the guilty parties. The shipping of tags and mailing of registration cards forms a large part of the work of the division. An adequate inspection force distributed throughout the State is essential to the enforcement of the motor laws.

Auditing and Accounting Division.—The functions of the auditing and accounting division consist largely of the budgeting and auditing of accounts, and cost accounting. To this end their work should be grouped upon the following basis: Pay rolls, invoices, and expense accounts, bookkeeping, and cost accounting, these branches handling the issuance of checks and all details incident to the payment of labor, the auditing and payment of invoices and expense accounts, bookkeeping and cost accounting, respectively.

The divisions which have been mentioned will in the majority of cases be applicable to most highway organizations, and additional units may be created as the need arises, keeping in mind always the logical grouping of functions, and the establishment of the same principles of control. Thus a department may grow indefinitely and yet preserve its balance.

DISCUSSION OF MR. BILES'S PAPER.

C. M. Babcock, commissioner of highways, Minnesota: It seems to me it simmers down to the point as to what are the duties of the highway department, before you can determine the policy of administration. Mr. Biles, in his paper, referred to the passage of laws giving power, when deemed expedient, permitting the acquisition of property and the construction and the building necessary for the manufacture of road material. I don't believe that the function of the highway department is that of manufacturing any materials that enter into the road construction problem.

One of the greatest difficulties is not in getting materials; it is in having those materials hauled by the railroads. Therefore I maintain that if it is necessary at this time for us to enter into the manufacture of road building materials it is doubly important that we go into the construction and actual building of the railroads in order to get materials on the roads so we can build our highways.

It seems to me that the duties of the highway department should be confined to the actual construction of the roads, the acquiring of the rights of way, the building and construction of highways and the structures incidental thereto. When we accomplish that and assume that burden in the various States, it seems to me that we have placed upon our shoulders one of the largest responsibilities there is any State department to-day. In trying to shoulder upon the highway departments the manufacturing and the building of road materials, as well as the handling of automobile road construction, we are doing wrong in my estimation. I believe, as stated before, that those things should be handled by other subdivisions of the State departments, and not by the highway department. The highway department should confine its efforts exclusively to the construction and building of highways.

There is a tendency in all highway departments of all States, as well as in Federal departments, to overorganization, and to the creation of too many bureaus. There are too many bureaus within the bureau. What we want is business administration. We want an organization that will handle things in a business way, and efficiently. They should be able to give you the actual cost of the different types of road in different sections of the State. And if an organization is properly organized it will be able to give you that.

NEED BUSINESS ORGANIZATION.

In handling our road problems in the various States, it is necessary that we organize on business lines. We are placed in a position of trust. The position is one that involves the expenditure of millions of dollars. Summing it up, as the attorney general said to me back there, "Your function here is simply to see that the State's money and the moneys placed in your hands are not squandered. In other words," he said, "You are to see that you give the public dollar for dollar for all the money that passes through your hands."

That is a large responsibility, but it places itself right back on the same basis as any business organization. Take the banking business, for instance: You people invest your money in the banking business. You put a man in charge of that bank. You expect that man at all times to safeguard your principal? Yes. And what else? You also expect him to return you a dividend at the end of the dividend period, and if he doesn't do that, what do you do? You immediately "chop off his head" and employ some other man.

If we do not handle our road proposition in such a way as to get results what will happen? The fact that large sums of money are being appropriated is not in itself sufficient for the building of roads. The fact that we have millions of dollars down at Washington, have millions in various State treasuries, available for road purposes, does not better the condition of the road one bit until the contracts are let and the roads are actually built.

It is results the public demands. It is not the acquiring of large sums of money, it is results, the finished product. And it is the finished product we have to have. That is what we must look forward to, not to the creation of bureaus within bureaus, and the overorganization of our departments. That is not the idea. What we must have, in my opinion, is the simplest form of organization, strictly along business lines.

A National Program for Highway Research.

ANSTON MARSTON, of the Iowa State Highway Commission, Ames, Iowa.

THERE is very urgent need for the immediate inauguration of scientific highway research in accordance with a comprehensive National program. The country is about to spend untold billions of dollars in the construction of paved roads. Yet there is a very serious lack of the fundamental scientific data which are absolutely essential to the correct design and construction of paved roads. In this respect we are still in the situation of the bridge engineers prior to 1850, who were building bridges without knowing how to compute the stresses in the different members; or in the situation of the sewerage and drainage engineers, who have learned only within the last few years how to determine the weights which must be carried by sewer pipe and drain tile laid in ditches.

The stresses in pavement slabs due to traffic, the effect of impact and abrasion, of variations in temperature, of nonuniform foundations, the cost of the various elements of highway transportation and the effect upon each element of each item of road improvement, all these and many other fundamental things require very extensive scientific experimentation to develop the true foundation principles of really scientific highway engineering.

AGENCIES FOR HIGHWAY RESEARCH.

(*a*) The American Association of State Highway Officials has already taken measures to coordinate highway research by the various State highway departments by establishing a test and investigation committee, which is already organized and which has been doing some very good work this year.

Undoubtedly every State highway department is a potential agency for important highway research, and no National program for such research can be made successful without the cooperation of the highway departments.

(*b*) The United States Bureau of Public Roads.—The United States Bureau of Public Roads is undoubtedly spending more money at the present time in direct scientific highway experimentation than any other agency. The work in devising instruments for measuring stresses in pavement slabs and in the subgrades, and the actual measurements of the effect of impact, etc., are already of great value.

(*c*) The road laboratories of engineering colleges and engineering experiment stations.—Many of these laboratories are well equipped and can undoubtedly be enlisted in a highway research program.

As illustrating such work already under way, it may be said that the Iowa Engineering Experiment Station is required, by State law, to spend at least $10,000 annually of its funds for road experimentation, and that it is actively engaged in a research on the determination of all elements of cost of highway transportation and the effect upon each element of cost of highway transportation of each element of road improvement, upon which investigation it proposes to spend at least $7,500 per year for a period of several years.

(*d*) Municipal testing laboratories are available in a number of large cities which could do valuable work.

(*e*) Manufacturers' research departments and associations should be able to render valuable assistance.

(*f*) Commercial laboratories.

(*g*) Technical societies.—The great National engineering societies can render effective assistance in organizing a national program, and in determining the use to be made of the scientific data to be secured.

(*h*) Consulting highway engineers.

It must be apparent that there is need for coordinating these eight research agencies in order to insure covering the entire field of highway research adequately and without unnecessary duplication of effort.

A PLAN FOR A NATIONAL PROGRAM.

A number of conferences have recently been held by representatives of highway laboratories, of State highway departments of the United States Bureau of Public Roads, and of the National Research Council, at which a tentative outline plan for a national program of highway research has been evolved.

This tentative plan is to organize six research committees, each to have charge of a definite line of highway research, and each committee to have representatives from all the various agencies to be enlisted and from all sections of the country.

Each of the eight research agencies in this country, as enumerated above, will of course take active part in organizing the national program of highway research (otherwise it could not be a success), and the cooperation of the engineering division of the National Research Council has been asked.

The National Research Council has been organized by the National Government for the general purpose of organizing and coordinating scientific research of this character. The engineering division of the research council has acted favorably upon the general plan here outlined, and I speak as a representative of that division, as well as a member of this association, in presenting the plan at this time.

COMMITTEES RECOMMENDED.

The six highway research committees recommended are as follows:

(1) Committee on the economic theory of highway improvement.—Purpose: Determination of all elements of cost of highway transportation (both motor vehicle and animal drawn) and the effect upon each cost element of each element of highway improvement (improved surface, grade reduction, elimination of rise and fall, etc.) to enable reliable and scientific determination of the sums which could be economically expended for specific highway improvements.

(2) Committee on structural design of roads.—Purpose: Experimental determination of stresses, strains and behavior, of impact and abrasion, in actual roadways under actual traffic, including also the effect of temperature variations, freezing and thawing, non-uniform subgrades and other factors, in order to establish reliable scientific theory for the structural design of roads.

(3) Committee on properties of road materials.—Purpose: To investigate the properties of road materials and their combinations, including devising and standardizing tests.

(4) Committee on methods of road construction.—Purpose: To collect and disseminate information on the various methods of securing efficient results in road construction, under various conditions and in the different parts of the country.

(5) Committee on maintenance methods and design.—Purpose: To collect and disseminate information on the various maintenance methods and the principles of maintenance design which are found to give best results under different conditions in the various sections of the country.

(6) Committee on highway bridge and culvert research.—Purpose: Investigation of the waterways required for different classes of culvert and drainage areas. Investigation of the distribution of wheel loads over bridge floors. Other unsolved problems of highway culverts and bridges.

The author believes that the executive committee and the tests and investigations committee of the American Association of State Highway Officials should now proceed to cooperate actively in organizing and making a success of some national program of highway research, such as outlined, or some other practicable program in which all the research agencies can be enlisted. The organization of each committee should be worked out in such a way as to provide adequately for representation from the State highway departments of the country, as determined by the executive or tests and investigations committees. There are very many ways in which the many State highway departments can cooperate in the actual researches. In fact, many of the researches can not be made successfully without the active cooperation of the State highway departments. There are many data needed which can be collected best by them. Our executive and tests and investigations committees should (and I think they do now) have full authority to act for us in cooperation in a national program of highway research.

DISCUSSION OF MR. MARSTON'S PAPER.

L. I. Hewes, Bureau of Public Roads: Are there not two general categories into which all questions of highway engineering may be placed—those that are economic and those that are technical? And is it not true that the engineer in the past has almost completely neglected the economic side of his profession, and is that not one reason why he has held a subordinate place in the larger generalship of those matters with which he has to deal?

In the matter of financing highways, the question was never raised to my knowledge as to how much a given community could afford to invest in its highways. The question was never raised as to the term of the bond and for years they adopted the suggestion of the bankers that a 30-year bond for highways was the desired term. If you will examine the statistics you will find that the banker suggested a bond which gave him the maximum profit. After the 30-year period he could hardly demonstrate to the public that it was advantageous to them to continue the life of the bond, but he showed that upon that bond there was a great diminution in the amount of the sinking fund required per year; he didn't tell you how much interest you were paying. You know now that it is not a good policy to run bonds beyond 15 years, and probably not beyond 10 years, in order that you may have an asset behind your liability. That is an economic question which the engineer completely neglected.

IMPORTANT ECONOMIC QUESTIONS.

There are other important economic questions. For example, one has been raised this morning with reference to the bonding of contractors. It has been said here time and again that this body of men has to spend the greatest amount of money that any single body of men has ever been called upon to expend, yet they are willing to relegate the determination of the amount of the bond to outside people without taking a slide rule and computing what is an equitable charge on these bonds.

The relation between the cost of construction and the cost of maintenance has not been given sufficiently sincere consideration by these people who are building the roads. There is no enthusiasm about maintenance. There is a great deal of enthusiasm about new construction. What is the proper relationship between the amount of money we should spend and the amount we should reserve for maintenance?

How this program is going to hold in 10 years is another economic question. We have at least 5,000,000 motor vehicles. They have cost $1,000 apiece, which represents $5,000,000,000 invested in rolling stock on our highways. They tell us that the machines are junked once in 5 years. But suppose they are only junked once in 10 years? Suppose the junking process is due only 50 per cent to the roads? See how much that is, and capitalize it, if you please. How much can you afford to spend to avoid having that waste by improving your highways? Those questions are economic ones.

I don't believe we know enough about the construction of concrete roads. I think Mr. A. N. Johnson published a table in the Engineering News-Record recently in which he showed 30 different mixings of concrete, using gravel and broken stone as aggregates. We need to know the effect of bulk and waste on concrete and bituminous structures. We are almost in total ignorance.

QUESTIONS TO BE ANSWERED.

The question is continually raised about impact on the road. We do not know anything about rolling friction. If you will look up the literature on the subject in any library you will find it is almost a total blank. Some of you who were at Detroit at the convention some years ago probably saw that machine which tested competitive types of pavement by pounding them with a horseshoe. We didn't forsee then that that horseshoe was to be taken off the pavement. We have a condition to-day which approximates a plane surface on which we are rolling cylinders. If a wheel is a perfect cylinder and the road is a perfect plane, how will you get impact?

The question has been raised, What is the economic depth of concrete roads? I think Mr. McClintock, of Massachusetts, was the first man in the United States to segregate road stones into different sizes, and he must have been forced to choose the size of stones by their relation to the thickness of the road he proposed to build. Are there any governing factors in the size of the aggregate? Considering that for a moment in relation to the recent discussion regarding the area theory in the use of cement, ask yourself the question: Couldn't you use 4 or 5 or 6 inch aggregates and build roads beyond all possibility of breaking up while using no greater amount of cement?

Now the question of width. It is surprising that a body of technical men should be so under the influence of conditions. What has determined the width? The width has been determined by the gauge of the old farm vehicle and the one-horse chaise. We are going to spend billions of dollars and be responsible not merely for not keeping up with things, but for not having foreseen things. The question is, How wide should we build our roads? That has been touched on only very lightly.

If we can not answer these questions, then why should we complain if commercial interests and other interests come to us and say, "This is what you shall do."

TO MAKE RESULTS KNOWN PROMPTLY.

Mr. MacDonald, Chief of Bureau of Public Roads: In discussing the nation-wide program of research, a number of the executive officers of highway departments have found it somewhat difficult to enthuse very much over such a program because of their fears that if this program were handled by a national committee the results would be delayed until after the roads are built. I believe it would be well if Mr. Marston would define what function the National Research Council proposes to exercise in connection with such a program, and make it very clear that the results, however obtained, will be immediately available; and that the National Committee on Research is not to be particularly a reviewing body, or the investigative body, but simply the correlating body.

Mr. Marston: What we propose is best explained perhaps by taking up the case of one of these committees, say, that which has to deal with the experimental investigations of pavement slabs, which has been mentioned. A chairman would be selected and on that committee would be appointed members representing the various agencies which could be induced to undertake the work, representing different sections of the country.

Certain work on that particular subject is already underway on quite an extensive scale. Such work will continue as a part of the program of this committee. The bulletins giving the results of all work will be published as often as there is anything to publish, perhaps more frequently than annually, so results will be available immediately.

The National Research Council merely fulfills the function for which it was organized by the United States Government, that of taking the initiative and of coordinating the work of all investigators, so that they will not cross each other's field, and so that the whole field will be covered adequately. The results are to be taken right off the griddle, as it were, as the meal proceeds.

Shall Contract Bonds Be Eliminated?

W. G. THOMPSON, State Highway Engineer of New Jersey.

ONE of the reasons advanced for the elimination of contract bonds is that they cost a great deal, and, in the opinion of one of my correspondents, are unnecessary to a very large extent. For instance, a contract for which the contract price is, say, $300,000, will in most States require a bond for the full amount of the contract, or a $300,000 bond. That costs the contractor a considerable amount of money, and is bound to be included in his contract price when he bids. No man is going to assume an obligation of perhaps $1,000, $2,000, $3,000, or $4,000 on a contract and not make the State or the governing body pay for it.

The argument has been advanced that you always have sufficient money withheld from the contractor to paralyze him if he withdraws from his contract or performs it in an unsatisfactory manner. In New Jersey we withhold 20 per cent of each monthly payment until the completion of the work. So you see we are quite well protected up until the end of the job. Really, on a $300,000 contract, we have $60,000 withheld. Now, a reputable contractor would be quite jealous of his reputation in the first place, even if there were no compelling clause, and in the second place he is going to think a lot about giving up $60,000 which is the withheld percentage on the $300,000 contract.

It seems to me the subject is very well worth serious consideration. Some of our members here have said that they do not wish contract bonds eliminated, however. When we consider the enormous expenditure now in prospect for highways during the next two or three years, the percentage of the total amount to be paid by governing bodies for the privilege of exacting the full amount of the contract as a bond will cost the State a great deal of money.

There has been up to date, of course, in most localities an insufficient number of reputable contractors to carry on this work. This is because of the fact that the programs have grown so rapidly that contractors in other lines of work have been unable to adapt themselves to the new conditions, and are therefore not altogether competent to carry on highway construction properly. Yet with the experience and training of the past two years we are getting together a pretty fair aggregation of highway contractors.

With these premises I present the subject to you. As I see the matter, we are to offset the rather vague advantage of requiring the full amount of the contract as a bond for proper and faithful performance against the enormous cost to the State that is absolutely lost to the ultimate object of road construction. It will undoubtedly amount during the next five years to hundreds of millions of dollars worth of actual road construction lost to the State because of the money paid the contractors for the bond requirement.

DISCUSSION OF MR. THOMPSON'S PAPER.

Frank R. Rogers, State highway commissioner, Michigan: We have had more or less trouble with the matter of bonds. As a matter of fact, I might say that we are required in Michigan to take one bond from a contractor, which is a statutory provision, guaranteeing the payment for labor and material. We can not eliminate that. The law says nothing about the size of the bond, or whether it shall be a surety bond or a personal bond.

We have some difficulties with the bond companies. In the first place, regardless of the size of the bond, they figure the fee on the size of the contract. If it is a $100,000 contract, and we only exact $20,000 bond, they charge 1½ per cent on $100,000, yet assume no liability beyond the size of the bond, which is very unfair.

We have found it necessary or at least advisable in certain instances to take personal bonds in small matters such as small bridges for instance. We have a line of contractors who are good mechanics. They have not a very great capital, and the hardship of a surety bond sometimes is considerable. In the first place, the surety companies insist on having enough money behind the contractor (either of his own or his friends) to guarantee the surety company before they put up a bond to guarantee the State. That does not work very well.

Up to date, I will say frankly, we have had as much trouble with surety bonds as with personal bonds, if not a little more. The matter of personal bonds is more serious in a local community, where the bonds are for persons who have friends who can make their influence felt in the common council or county board than in State work, where the person bonded has no such friends at court.

We may have some trouble with personal bonds on a few contracts. It is pretty hard to strip a man of all he has when he has given a personal bond, and you do not feel that way about the surety-bond companies. However, our experience is that the surety companies are past masters in taking advantage of every detail. If there is a slip anywhere they know how to get out of the responsibility. So there is more or less trouble that way.

It is a pretty hard problem. I put up to our advisory board at the first meeting the question of the possible unfairness involved in exacting a surety bond in some instances and in other cases taking a personal bond. I asked them if we should lay down an ironclad rule in all cases. I told them about the small contractor and our troubles, that it might eliminate the small contractor entirely, that, in fact, it would be impossible to get contractors to bid on certain jobs if we required a surety bond. They decided we had better use our judgment as in the past.

NOT WISE TO ELIMINATE THE BOND.

It is a seriously complicated and difficult question, although it never occurred to me that there was any possibility of getting away from the bond entirely, and I do not think it would be wise in our State. We couldn't do away with it entirely, and I don't think it would be wise to leave out the bond for the faithful performance of the contract. although we seldom take a bond for more than 50 per cent of the main contract; and if it is a contract which is largely a labor proposition, and very little material is purchased from a distance, so that freight charges are small, we sometimes make that bond as little as 25 per cent of the contract.

George E. Johnson, state engineer, Nebraska: We do not think it wise to discontinue the bonding of contractors on highway work, for two reasons, one that appears ridiculous. In the first place, we get a good deal of the money you fellows put into bonds; in the second place, a bond is a form of insurance against possible loss, and if you carry the principle of discontinuing bonds through the whole matter of contracting you will come to the conclusion that you do not need any insurance at all. It is perfectly true many of us never collect from bonding companies. But once in a while we do get caught very badly. The State of New York during the last two or three years has been caught by unreliable contractors on a number of occasions. For these reasons I think the use of surety or personal bonds is advisable.

Guy Miller, Bureau of Public Roads: I think as much of the trouble in New York was due to war conditions as to unreliability of contractors. Having figured up the premiums they have been paying, and the cost the bond companies have put them to in court, and having balanced those against the recoveries from the bond companies, New York is now accepting a bond for 50 per cent and withholding 10 per cent of the contract as the monthly payments come in; or, at the option of the contractor, they will not require a bond, but in that case will withhold 20 per cent. As I see it, it is a matter of balancing of cost. They figure the cost will be less by the new plan than by continuing bonds.

Mr. Johnson. As soon as we adopted the policy of allowing personal bonds the bond companies came down a half a cent on contracts.

TOO MUCH PAID OUT FOR BONDS.

Mr. Coykendall, engineer of road management, Iowa: We require surety bonds for anything above $1,000. I suspect that some of the bond companies' agents boosted that law. It is, at least, a very good one from their standpoint. We have seriously considered the advisability of legislation allowing the State to carry insurance. Of course that is something we would have to get through the legislature, but it looks as if the expenditure for bonds is entirely out of proportion to the protection they give us.

With the projects we have on hand we can well afford to carry insurance. We have also considered the possibility of getting up a black list of contractors that are inclined to take advantage, if the bond provision should be stricken out of the law. If that is done, it would be well, we think, to attempt working the same kind of arrangement with other States. But, as indicated before, we are paying out of all proportion to the value received from the bonds.

H. J. Knuelling, construction engineer, Wisconsin: If all these large manufacturers can carry their own fire insurance, and a great many carry life insurance for their men, I can not see any reason why the State is not big enough to be its own insurance company.

SURETY AND PERSONAL BONDS.

M. W. Torkelson, bridge engineer, highway commission, Wisconsin: The Wisconsin Commission has had quite a battle over this question of bonds. We have adopted the scheme the past year of admitting either surety or personal bonds—that is, we determine whether or not we will permit a man to give a personal bond. On a considerable part of $1,000,000 worth of work 56 per cent had surety bonds, and 44 per cent had personal bonds. We look up the Dun or Bradstreet rating of the man before we will accept a personal bond. We think that, with the amount of work we are handling, we are just as able to do that as a bonding company is.

Our trouble with surety bonds is the very large charge the surety companies must make to cover overhead expenses. We have found that some of the old-line liability companies have overhead expense for agents' commissions and other purposes amounting to 45 per cent, that never goes into protection at all. For some mutual companies such expenses run as low as 13 per cent. For that reason we have been encouraging our contractors to use the mutual companies for liability insurance, and there are some mutual companies that are as reliable as old-line companies.

There is one advantage, however, of the bond in the surety company. A poor contractor can not get a bond. In that way the surety-bond requirement helps to eliminate some of the overzealous fellows who want work and are not able to do it when they get it.

There is another point that is sometimes overlooked which is illustrated by a contract we had for $200,000. The rate was 1½ per cent, which would make the cost of the bond $3,000. The contractor wished to sublet the major part of that work. As our State doesn't recognize a subcontractor, the bond of the subcontractor had to read "direct contractor," and the subcontractor had to pay 1½ per cent, making the amount the State finally had to pay on that bond 4 per cent or over, depending on the amount of the subcontract. The rates sometimes run higher than a bonding company will admit.

In a series of years of work there have been only two cases in my experience where a bonding company has been called on to pay. We have three, I think, we will lose now. If you add up the losses you have with the premiums you have paid, I think you will get extraordinary results.

J. H. Mullen, chief engineer, Minnesota: We pay between $150,000 and $175,000 a year on surety bonds in Minnesota. I don't believe we have had recoveries from the bonding company to exceed $3,000 or $4,000 a year. We have not had to go to the bonding companies to collect on a bond. There has been a waste of over $100,000 a year, I believe. Mr. Thompson's idea is good; we could carry our own insurance to good advantage, paying a little more attention to the responsibility of the contractor, his resources and ability to handle the work, and devise some other means than exacting 1½ cents on every dollar's value in a job.

AMERICAN RAILROAD ASSOCIATION TACKLES THE CAR SERVICE PROBLEM.

The commission on car service of the American Railroad Association has issued the following circular, CCS-7, in regard to car service for the transportation of road-building materials.

To Railroads:

Information reaching the Bureau of Public Roads of the United States Department of Agriculture, from various State highway commissions, and from producers of materials used in road construction, indicates that there will be an extraordinarily heavy movement of these materials during the coming season. It is estimated that the road building this year will not be be less than three times that of the heaviest previous season. The transportation demand will be accentuated by reason of the fact that much of the road construction will be in territory where stone, sand, and gravel deposits are so located as to require abnormally long hauls.

It seems to be apparent, from what has already been brought to our attention, that the handling of this business will require some cooperative action between individual railroads and the commission on car service in order that maximum use of equipment and adequate service for this traffic may be secured. It is suggested, therefore, that individual carriers should, as promptly as possible, ascertain the demands that will be made upon them, and in the event that relief seems necessary, the commission on car service should be promptly advised of all the facts so that the necessary steps may be taken looking to such readjustment of car movement as is possible in individual cases.

W. C. Kendall, *Chairman.*

State highway departments and county and municipal road and street officials can render invaluable assistance to the railroads and, at the same time, promote their own interests, by at once notifying their local railroad officials, as to the probable tonnage of materials they will require during the coming construction season.

The commission on car service is a body which has been formed, since the return of the railroads to private ownership, by the American Railroad Association. In large measure, it will take over the duties of the former car-service section of the division of operation of the United States Railroad Administration. The new commission is composed of W. C. Kendall, chairman, A. G. Gutheim, W. J. McGarry, and W. L. Barnes.

Already by a joint agreement with the principal railroads of the country, the commission has increased the per diem rates on freight cars in transit on freight rails from 60 cents to 90 cents per day. By this means it is hoped to speed up the transportation business of the country so that the shortage of cars, amounting to about 80,000 monthly, may be at least partially overcome.

As a further means of speeding up the freight transport facilities of the railroads the commission has recently held conferences with superintendents of transportation and of railroad yards.

STATE TESTING ENGINEERS AND CHEMISTS MEET IN WASHINGTON.

DURING the week of February 23 a meeting of State highway testing engineers and chemists was held at the Bureau of Public Roads in Washington under the auspices of the committee on tests and investigations of the American Association of State Highway Officials. The purpose of this meeting was to formulate standard methods for testing road materials, to standardize methods for sampling, and to establish safe test limits for incorporation in specifications.

Prof. T. R. Agg, chairman of the committee on tests and investigations of the American Association of State Highway Officials, acted as chairman of the conference.

Those present were:

T. R. Agg, consulting road engineer, Iowa Highway Commission, Ames, Iowa.

B. A. Anderton, chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

R. H. B. Begg, professor of civil engineering, Virginia Polytechnic Institute, Blacksburg, Va.

J. G. Bragg, senior testing engineer, New Jersey State Laboratory, Quarry Street and Taylor Place, Trenton, N. J.

L. G. Carmick, assistant chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

W. F. Cooper, office engineer, Louisiana State Highway Department, New Orleans, La.

R. B. Dayton, testing engineer, West Virginia State Road Commission, Mechanical Hall, Morgantown, W. Va.

A. W. Dean, chief engineer, Division of Highways, Department of Public Works, State House, Boston, Mass.

R. B. Gage, chemical engineer, Taylor and Quarry Place, Trenton, N. J.

A. T. Goldbeck, engineer of tests, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

J. F. Grimes, assistant road engineer, Frankfort, Ky.

H. B. Hinderlite, Raleigh, N. C.

G. W. Hutchinson, testing engineer, State Highway Department, Dover, Del.

F. H. Jackson, senior assistant testing engineer, Bureau of Public Roads, Washington, D. C.

F. C. Lang, engineer of tests and inspection, University of Minnesota, Minneapolis, Minn.

H. Walter Leavitt, testing engineer, Maine State Highway Commission, University of Maine, Orano, Me.

Frederick T. Maddocks, testing engineer, California Highway Commission, Forum Building, Sacramento, Calif.

W. D. Martin, Columbus, Ohio.

Henry M. Milburn, chemist, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

W. F. Purrington, chemist, New Hampshire Highway Department, 19 Thorndike Street, Concord, N. H.

A. S. Rea, engineer of tests, State highway department, Brown Hall, Columbus, Ohio.

F. L. Roman, testing engineer, Department of Public Works and Buildings, Division of Highways, 820 East Adams Street, Springfield, Ill.

F. C. Rossell, chemist, Maryland State Roads Commission, 601 Garrett Building, Baltimore, Md.

R. L. Saunders, deputy state highway commissioner, State Highway Commission, Hartford, Conn.

R. A. Seaton, professor applied mechanics, in charge road materials testing laboratory, Kansas State Agricultural College, Manhattan, Kans.

E. B. Smith, senior assistant testing engineer, Bureau of Public Roads, Department of Agriculture, Washington, D. C.

D. V. Terrell, professor of civil engineering and testing engineer, University of Kentucky, State Road Department, Lexington, Ky.

Malcolm H. Ulman, chemist, Pennsylvania State Highway Department, Harrisburg, Pa.

M. O. Withey, testing engineer, Wisconsin Highway Commission, Madison, Wis.

The conference was divided into four committees:

1. Committee on tests of concrete and concrete materials.
2. Committee on tests of other nonbituminous materials.
3. Committee on tests of bituminous materials.
4. Committee on test limits for specifications.

As a result of the conference standard methods of sampling and testing bituminous and nonbituminous materials were adopted and a report of the committee on test limits for specifications was received, although not adopted by the conference.

During the progress of the conference the following papers were presented on subjects that seem to be of special interest at this time:

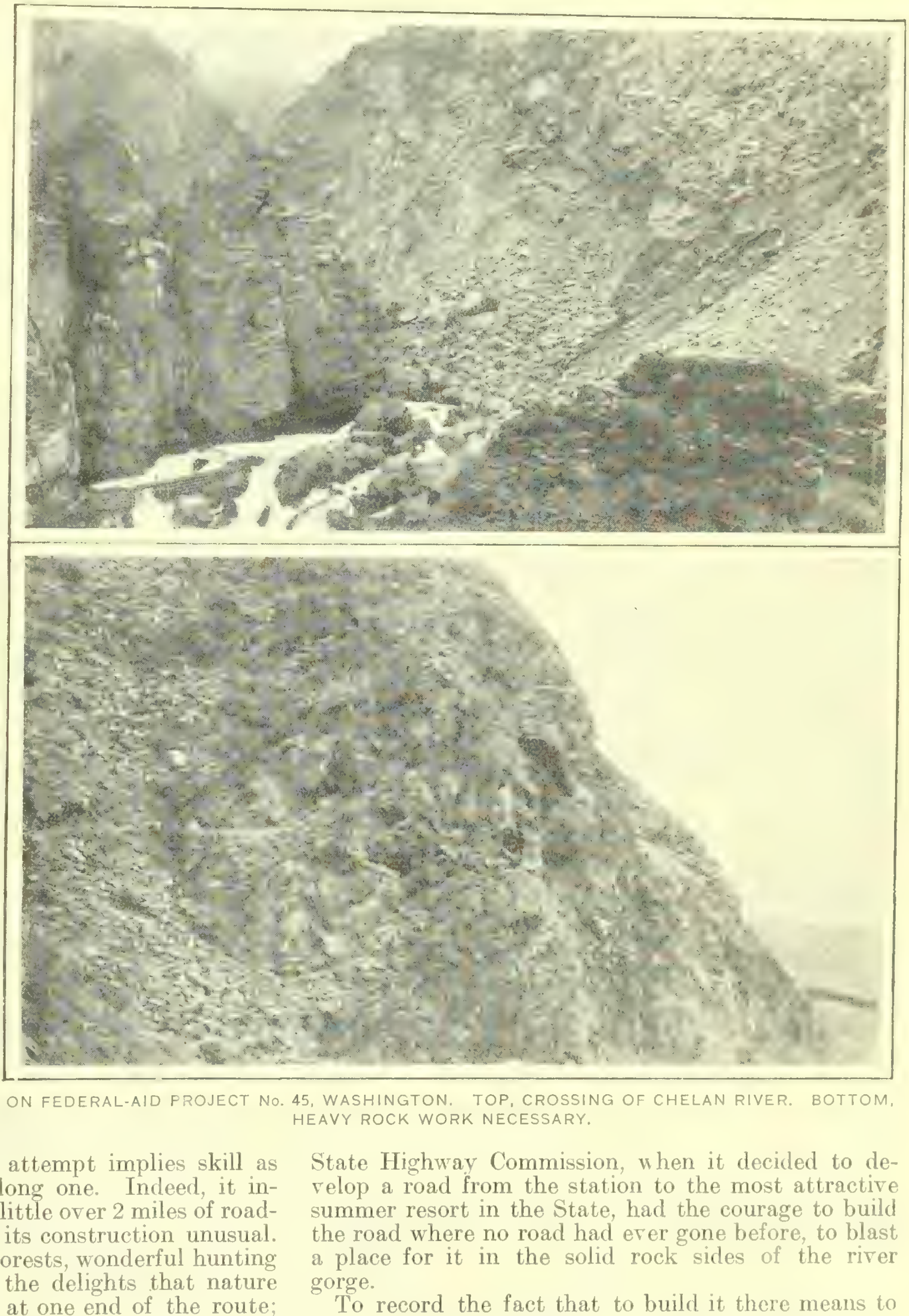
Penetration Limits for Asphalts for Different Types of Construction. By Prevost Hubbard of the Asphalt Association.

Blast Furnace Slag, by the Slag Association. Read by Mr. W. D. Brewer.

The Fineness Modulus Method for Proportioning Concrete. By Prof. D. A. Abrams, Lewis Institute, Chicago, Ill.

It is expected that the proceedings of this meeting will be available for distribution in bulletin form some time in the near future.

INTERESTING FEDERAL AID PROJECT.



ON FEDERAL-AID PROJECT No. 45, WASHINGTON. TOP, CROSSING OF CHELAN RIVER. BOTTOM, HEAVY ROCK WORK NECESSARY.

IN THE building of highways as in other clases of construction work the unusual is always of interest. It is the tallest building, the biggest ship, the longest bridge, which attract attention, and justly so, for such works are measures of unusual attainment and, as such, are powerful stimulants urging others to equal or to greater effort.

One, therefore, looks for the unusual in highway construction, not because it has any special bearing on the every-day activities of the highway engineer, but because successes under difficult conditions are a measure of the courage and of the resourcefulness of the men who have dared to push forward in the face of unusual difficulties. If it were not for such men the profession would lag, and if it were not for knowledge of the works which they have constructed, courage to go forward would often be lacking.

Such projects as Washington Federal aid project No. 45 are, therefore, of special interest, for to attempt the unusual requires courage and resourcefulness and to succeed in the attempt implies skill as well. This project is not a long one. Indeed, it involves the building of only a little over 2 miles of roadway. Nor is the purpose of its construction unusual. A lake of rare beauty, large forests, wonderful hunting and fishing, in short, all of the delights that nature can put in a single region lie at one end of the route; at the other, a prosaic railroad station. Between there is a rough and rugged mountain. For years all who have gone to the lake from the station have climbed this rugged mountain. It is true that there has always been another way, for the river which runs out of the lake long centuries ago cut a path through the mountain. But no one went by this way; the sides of the river gorge were too steep and the river itself too deep and too dangerous. It remained, therefore, an untraveled way, but it will remain so no longer for the Washington State Highway Commission, when it decided to develop a road from the station to the most attractive summer resort in the State, had the courage to build the road where no road had ever gone before, to blast a place for it in the solid rock sides of the river gorge.

To record the fact that to build it there means to move more than 80,000 cubic yards of material, over half of which is solid rock, would be to infer that such projects can be measured in tons of material or in dollars of cost. But they can not be so measured. It is not the rock that is moved or the money which is spent that renders such projects monumental, but the daring and the imagination of the engineer who is willing to cut a new trail where none has ever been before, because, as an engineer, he believes the new location to be the proper one.

GRAPHICAL PROGRESS REPORT IN FEDERAL AID ROAD CONSTRUCTION.

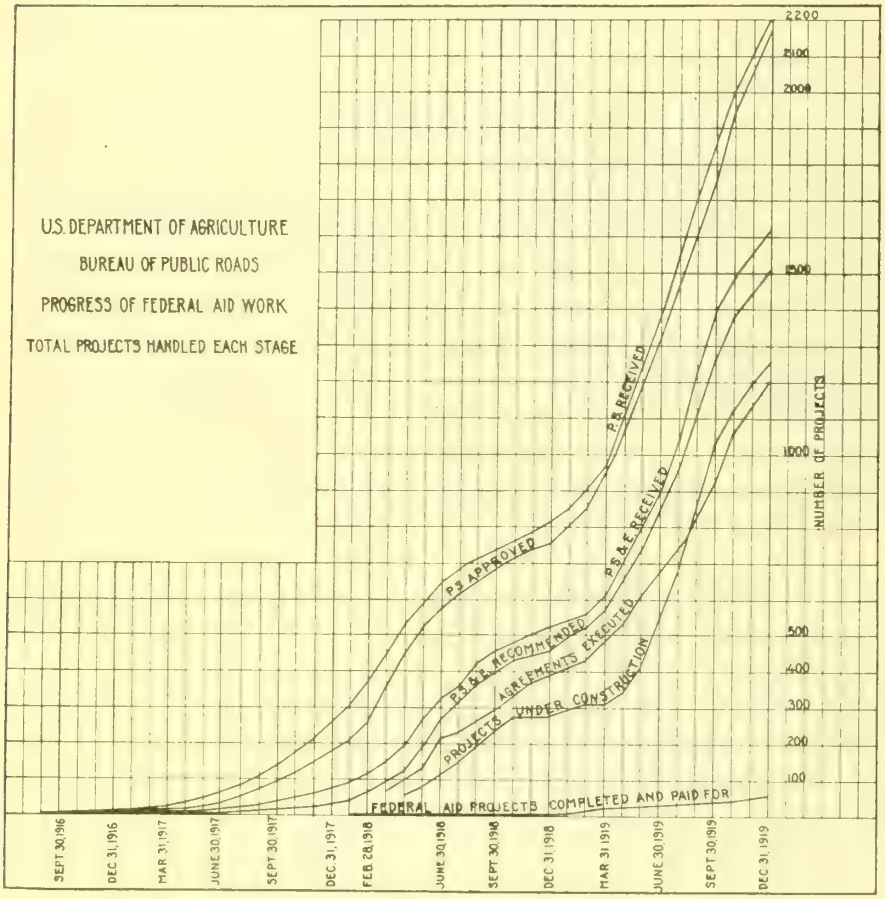


CHART SHOWING PROGRESS OF FEDERAL-AID WORK

WHAT is virtually a complete summary of the operations of the Federal Government and the States under the Federal aid road acts of 1916 and 1919 from the passage of the first law to the close of the calendar year 1919 is contained in two charts recently prepared by the Bureau of Public Roads.

The first chart, reproduced here as figure 1, shows the progress of Federal aid work by numbers of projects in the various stages from the initial project statement stage to the final completion and payment for the work.

This chart traces the development of this important work through the early days of comparatively small accomplishment, when appropriations were small and the States and Federal Government were laying the foundation for the great cooperative work which was to follow; through the lean years of the war when road building was put aside for the more important business of war; and through the period of accelerated accomplishment which, following immediately after the armistice and gathering new momentum from the passage of the second act on February 28, 1919, continued through the past year.

On December 31 last the States had filed 2,243 project statements of which 2,173 had been approved. Work on over 1,600 projects had proceeded to the stage at which the plans, specifications, and estimates are delivered to the Bureau of Public Roads; and project agreements had been actually executed and construction work was in progress on 1,200. In the meantime, however, work had been begun on about 50 projects for which agreements had not actually been signed, thus expediting the progress of the work.

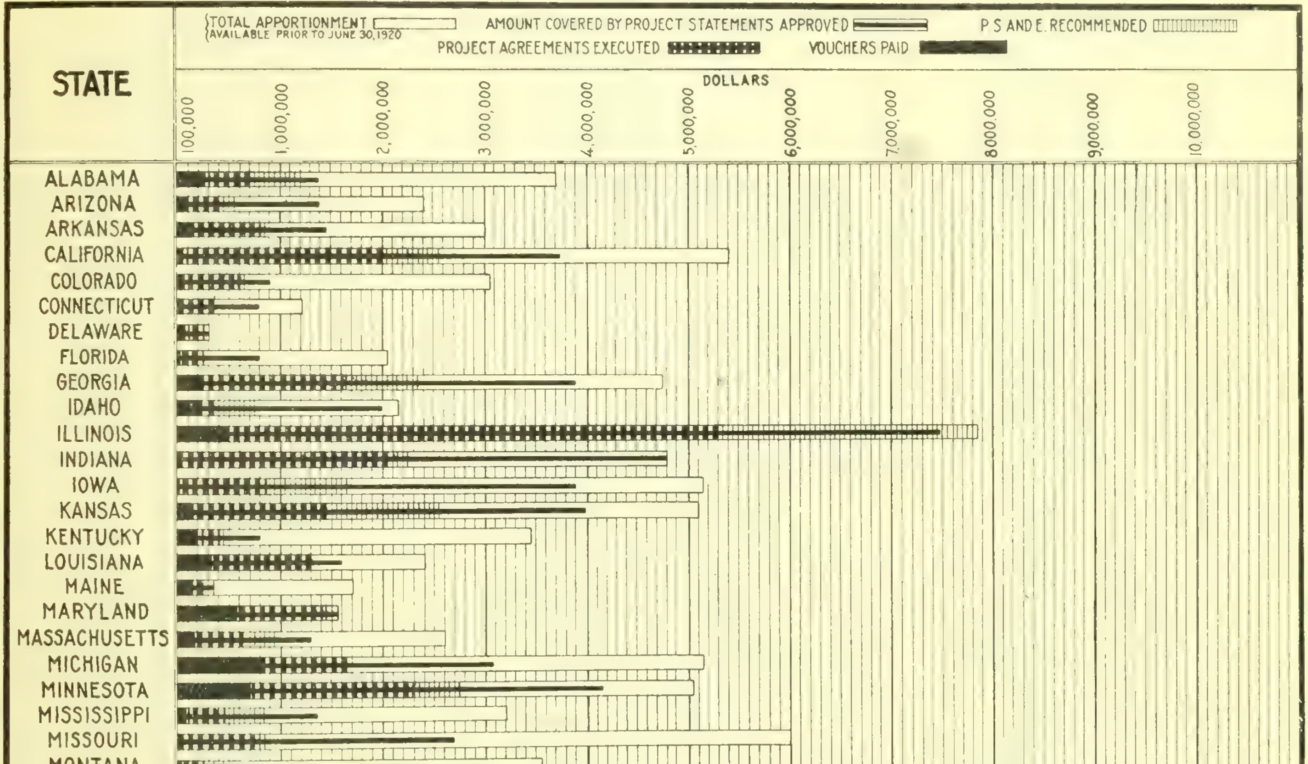
The projects actually completed and paid for are comparatively few, but they are materially exceeded in number by those which are practically completed. The coming year should develop a sharp rise in the curve representing the completed projects, as these projects are finally cleared and credited to the record.

One of the most significant facts brought out by the chart is the great reduction which has been made in the amount of time required for the preliminary work before actual construction work is begun. By closer cooperation and improved facility in handling the necessary preparatory work, this period had been so reduced that, at the height of the last construction season, it was little more than one-half as long as it was in the early stages of the work.

For those who are interested in the performance of particular States the second chart, figure 2, will contain interesting information. The various symbols show the total apportionment of Federal money to each State available prior to June 30, 1920, and the amounts of such money covered by project statements submitted and approved; plans, specifications, and estimates recommended; and project agreements executed; and finally the amounts actually paid on vouchers to the States prior to December 31.

The average State has submitted approved project statements for about five-eighths of its allotment, and has entered into agreement to construct highways which will call for about one-third of its Federal aid money. Vouchers have actually been paid this average State in the amount of less than one-tenth of its allotment. It should be remarked, however, that this latter figure is no fair indication of the value of the work which has been completed, as many of the States have funds which are so ample that they are able to carry on the work without requesting payment by the government while the work is in progress.

STATUS OF FEDERAL AID FUNDS BY STATES
(ON DECEMBER 31, 1919)



As work is finished which is now nearing completion, and the States' shares of Federal funds are paid, this figure should show a large increase.

The outstanding performances are those of Delaware, Illinois, Indiana, Maryland, New Hampshire, Ohio, Pennsylvania, and Washington, all of which have submitted approved project statements for all or nearly all of their allotments, have entered into agreements for about one-half or more of the funds available, and have actually received payment for work to the amount of from one-eighth to three-eighths of their total allotments.

DECEMBER AND JANUARY FEDERAL AID.

FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR DECEMBER, 1919.

State.	Number of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Arkansas	34	Cross	2.55	Gravel	Dec. 2	$26,427.50	$13,200.00
	37	Washington	14.35	Macadam	Dec. 5	47,099.80	15,000.00
	40	Hempstead	9.51	Gravel, macadam	Dec. 22	63,789.00	19,000.00
	45	Lonoke	6.49	Gravel and asphalt	Dec. 10	72,467.34	21,000.00
	50	Phillips	7.94	Warrenite on concrete base	Dec. 12	224,565.00	36,800.00
	54	do	7.71	do	Dec. 22	195,025.60	30,000.00
	55	Prairie	2.09	Gravel, macadam, and asphalt	Dec. 26	30,093.05	5,400.00
	56	Cleveland	4.00	Gravel	Dec. 23	18,541.60	8,700.00
	61	Benton	23.14	do	Dec. 20	70,796.12	34,500.00
California	39	Riverside	14.33	Concrete	Dec. 27	347,765.00	173,882.50
	41	Imperial	14.86	do	do	348,496.50	174,248.25
Colorado	29	Jefferson	1.946	Earth	Dec. 26	58,708.76	29,354.38
	31	Arapahoe	1.17	Cement concrete	do	43,957.10	21,978.55
	82	Jefferson	23.01	do	do	86,646.85	43,323.42
Georgia	109	Dawson	7.00	Sand-clay or topsoil	Dec. 20	51,564.34	20,000.00
	118	Fannin	3.50	Sand-clay	Dec. 26	31,600.80	15,000.00
	119	Pickens	8.00	Gravel or crushed stone	Dec. 20	48,239.44	15,000.00
	120	Carroll	8.10	Topsoil	Dec. 26	59,856.50	15,000.00
	121	Randolph	6.00	Sand-clay	Dec. 27	34,650.85	15,000.00
	122	Grady		Bridges	Dec. 23	23,760.00	11,800.00
	124	Washington	5.75	Sand-clay	Dec. 27	43,816.85	20,000.00
Iowa	65	Boone	22.50	Gravel	Dec. 10	132,558.25	66,200.00
	74	Clayton	32.20	Earth	Dec. 23	160,050.00	80,000.00
Kansas	38	Greenwood	5.90	Bituminous macadam or concrete	Dec. 12	275,484.00	58,500.00
	39	Crawford	5.00	do	Dec. 10	270,892.09	75,000.00
	40	do	12.00	Brick or concrete	Dec. 23	722,645.11	180,000.00
Kentucky	9	Todd	[1] 1.85	Macadam	Dec. 22	[1] 49,714.91	[1] 21,857.45
	16	Warren	2.75	Asphalt or bituminous	Dec. 8	50,000.00	25,000.00
Louisiana	23	Lafayette	10.42	Gravel	Dec. 10	129,897.53	64,938.76
	51	St. Charles	6.23		Dec. 23	62,531.15	31,265.57
Michigan	38	St. Clair	16.614	Concrete	Dec. 10	554,070.00	277,035.00
	43	Muskegon	21.892	do	Dec. 12	728,068.00	364,034.00
Minnesota	65	Benton	5.00	Gravel	Dec. 22	28,215.00	14,107.50
	80	Polk	11.85	do	Dec. 3	68,714.80	34,357.40
	97	Olmstead	14.54	Concrete, brick, or asphalt	Dec. 22	554,267.90	163,280.37
	100	Steele	8.10	Concrete, brick or asphalt	do	258,682.60	70,604.78
	113	Crow Wing	3.41	do	Dec. 16	118,831.68	35,649.50
	114	Sherburne	9.50	do	do	297,222.20	89,166.66
Mississippi	80	Adams	3.60	Gravel or sand-clay	Dec. 26	28,715.50	14,357.75
	84	Jefferson	35.35	Gravel	do	367,284.72	183,300.00
Missouri	32	Gentry	4.12	do	Dec. 16	84,475.05	42,237.52
	48	Platte	8.22	Brick on concrete foundation	Dec. 8	462,485.37	171,900.00
	50	Harrison	6.62	Earth	Dec. 23	65,619.40	32,809.70
	51	Howell	40.00	Gravel	Dec. 20	186,598.50	93,299.25
	52	Cape Girardeau	3.22	Concrete	Dec. 2	102,530.68	51,265.34
	53	Lawrence	22.00	Gravel	Dec. 26	82,999.89	41,499.94
	54	Gentry	8.58	Bituminous macadam	Dec. 12	181,537.40	90,768.70
	56	Jasper	4.00	Concrete	Dec. 26	88,000.00	44,000.00
	58	Butler	24.00	Gravel	do	268,323.00	134,161.50
	59	do	13.00	Gravel and concrete	Dec. 30	80,344.00	40,172.00
Montana	65	Teton	38.00	Gravel	Dec. 12	208,885.60	104,442.00
Nebraska	115	Platte	3.00	Concrete	do	106,099.40	53,049.70
	118	Thayer and Jefferson	24.50	Earth	Dec. 16	91,245.00	45,622.50
	121	Perkins	17.80	Earth and sand-clay	Dec. 4	63,725.20	31,827.60
	122	Gage, Johnson, and Powell	33.90	Earth	Dec. 26	109,043.00	54,521.50
	124	Dawes and Sheridan	34.40	Earth, sand-clay and gravel	Dec. 20	140,043.20	70,021.60
	127	Custer	23.40	Earth and sand-clay	Dec. 24	77,198.00	38,599.00
	130	Cheyenne	33.80	do	Dec. 8	137,038.00	68,519.00
	131	Pawnee and Richardson	24.10	Earth	Dec. 10	82,137.00	41,068.50
	134	Seward	17.90	do	do	63,717.50	31,858.75
Nevada	26	Washoe		Bridge	Dec. 26	74,855.00	37,427.50
	27	Clark		do	Dec. 23	153,168.40	76,584.20
Mew Mexico	39	Quay	1.00	do	Dec. 8	129,800.00	64,900.00
New York	24	Herkimer	[1] 1.06	Bituminous	Dec. 27	[1] 76,300.00	[1] 38,150.00
	31	Schuyler and Seneca	11.70	Cement concrete	Dec. 26	468,000.00	234,000.00
	33	Schoharie	10.34	Concrete	do	413,600.00	206,000.00
	36	Broome	4.40	do	do	176,000.00	88,000.00
	40	Oswego	9.70	do	do	388,000.00	194,000.00
	41	Orleans	2.05	do	Dec. 2	82,000.00	41,000.00
North Carolina	79	Cleveland	1.65	Concrete or bituminous	Dec. 10	45,730.96	22,865.48
	80	Montgomery	29.70	Topsoil	Dec. 8	323,825.92	161,912.96
	82	Davidson	5.70	do	Dec. 23	39,607.26	19,803.63
	84	McDowell	28.50	Sand-clay, topsoil, gravel, or shale	do	346,354.25	173,177.12
	85	Davie	8.252	Topsoil	do	43,421.40	21,710.70
	90	Pamlico	12.60	Concrete or other hard surface	do	231,497.20	115,748.60
	91	Surry	10.60	Topsoil	Dec. 26	72,294.53	36,147.26
	92	do	10.85	do	Dec. 23	89,952.28	44,976.14
	93	Franklin and Warren	23.00	Topsoil, sand-clay	do	95,960.92	47,930.46
	94	Mitchell	10.00	Bituminous	Dec. 10	113,084.40	56,542.20
	96	Yancey	3.00	Sand and gravel	Dec. 26	35,373.80	17,686.90
	98	Lee and Moore	34.80		Dec. 30	239,398.28	119,699.14
	99	Chatham	34.80	Topsoil	Dec. 23	273,531.28	136,765.64
	100	Avery	21.00	Macadam and gravel	do	229,735.00	114,867.50
	101	Randolph	19.30	Topsoil	Dec. 26	226,633.00	113,316.50
	107	Madison	3.00	Gravel or sand-clay	do	48,507.03	24,253.51
Ohio	69	Allen	3.14	Macadam or bituminous	Dec. 4	91,000.00	31,400.00
	74	Hardin	8.05	Bituminous or concrete	Dec. 10	228,000.00	90,000.00
	106	Jefferson	1.071	Brick	do	59,400.00	8,000.00
	107	Warren	6.865	Bituminous	Dec. 4	187,000.00	93,500.00
Oklahoma	22	Comanche	6.00	Gravel	Dec. 8	76,096.50	38,048.25
	23	Pushmataha	4.60	do	do	65,632.40	32,816.20
Oregon	23	Lake	1.78	do	Dec. 12	15,364.80	7,682.40
	38	Umatilla	7.52	do	Dec. 27	110,771.10	55,385.50
South Carolina	37	Aitken	21.303	Garvel or sand-clay	Dec. 16	128,056.12	25,000.00
	40	Allendale	10.165	Sand-clay	Dec. 12	89,892.03	12,000.00
	44	Clarendon	7.916	do	Dec. 10	143,183.86	71,591.93
	47	Florence	5.981	Cement concrete	Dec. 23	216,511.75	84,000.00

[1] Revised statement. Figures given are increases over those in the original statement.

FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR DECEMBER 1919—Continued.

State.	Number of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
South Carolina	52	Saluda	4.56	Topsoil	Dec. 22	$64,314.44	$32,157.22
	53	Charleston and Colleton		Bridge	..do	68,129.38	34,064.69
	60	Beaufort		....do	Dec. 26	207,900.00	103,950.00
	82	Union	16.785	Earth and topsoil	Dec. 20	93,618.65	33,495.00
South Dakota	29	Carson	9.07	Gravel	Dec. 30	46,407.68	23,203.84
	30	Brule	8.30	....do	Dec. 18	72,503.20	36,251.60
	31	Beadle	8.50	....do	Dec. 30	67,875.50	33,907.75
	32	Edmunds	16.00	....do	Dec. 18	131,466.50	65,733.25
	33	Miner	11.10	....do	...do	81,339.50	40,669.75
	34	Spink	10.90	....do	Dec. 26	74,053.10	37,026.55
	35	Bon Homme	13.75	....do	Dec. 22	104,579.00	52,299.50
Tennessee	21	Carroll	12.273	....do	Dec. 2	201,119.63	100,559.81
	24	Marion	2.318	Macadam	Dec. 27	85,856.28	42,928.14
Texas	113	Hill	23.50	Gravel	Dec. 2	535,826.02	60,000.00
	119	Wichita	10.00	Concrete	Dec. 3	483,212.40	100,000.00
	122	Hill	17.00	Gravel	Dec. 30	315,182.23	40,000.00
	123	....do	12.82	....do	...do	145,370.70	25,000.00
	126	Collin	37.75	Macadam and gravel	Dec. 26	497,050.40	100,000.00
	127	Gillespie	18.90	Gravel	Dec. 30	112,378.75	24,000.00
Vermont	12	Rutland	13.65	....do	...do	302,446.10	151,223.05
Wyoming	45	Albany	2.705	Local material	Dec. 27	28,600.00	14,300.00
	52	Fremont	3.988	Sand-clay or gravel	Dec. 10	39,600.00	19,800.00
Total	119		1,419.99			19,054,127.56	7,798,946.61

FEDERAL AID, PROJECT AGREEMENTS SIGNED, FOR DECEMBER, 1919.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Arizona	9	Pima	3.79	Concrete or bituminous	Dec. 19	$116,018.00	$58,009.00
Arkansas	29	Craighead	5.62	Macadam	Dec. 26	79,714.80	33,000.00
California	27	Stanislaus	12.79	Concrete	Dec. 10	257,835.86	128,917.93
	28	Placer	6.68	....do	..do	137,303.70	68,651.85
	29	Amador	10.74	Earth	..do	71,828.59	35,914.29
Georgia	48	Clarke	3.785	Concrete	..do	83,262.97	41,631.48
Illinois [1]	[1] 9	7 counties	32.403	Brick and concrete	Dec. 30	1,112,096.59	551,108.60
	[2] 9	....do	25.496	....do	..do	930,063.07	465,031.53
Indiana	16B	Vanderburgh, Spencer, Dubois, Orange, and Lawrence.	10.275	Brick, bituminous, or concrete	..do	475,747.10	205,500.00
Iowa	84	Sioux	2.94	Brick or concrete	Dec. 10	108,185.66	54,000.00
Kansas	1AB	Mitchell	4.163	Concrete	..do	191,607.69	62,445.00
	21	Allen	3.25	Concrete or macadam	..do	67,073.63	33,536.81
Kentucky	14A	Nelson	1.849	Asphalt, rock, or bituminous	..do	44,444.45	22,222.22
Maryland	7C	Baltimore and Harford	.329	Concrete	Dec. 23	15,386.25	6,580.00
	10A	Montgomery	2.025	....do	Dec. 12	91,705.02	40,500.00
	12C	Carroll	6.63	....do	Dec. 10	250,679.23	125,339.61
	34A	Anne-Arundel	5.59	Gravel	..do	50,097.08	25,048.45
Massachusetts	14	Barnstable	3.331	Bituminous	..do	52,125.15	26,062.57
	28A	Berkshire	.989	Concrete	..do	41,274.75	19,780.00
Minnesota	42	Washington	7.201	Gravel	..do	75,243.05	35,000.00
	61	Freeborn	11.53	....do	Dec. 23	91,116.78	42,000.00
	69	Rice	4.30	....do	Dec. 26	21,584.29	9,000.00
	70	Cook	4.58	....do	Dec. 10	38,679.46	19,000.00
	73	Crow Wing	3.648	Concrete	Dec. 12	130,604.87	30,000.00
	101	Cottonwood	8.042	Gravel	Dec. 26	66,223.08	21,000.00
	111	Redwood	2.00	....do	Dec. 27	8,316.00	4,158.00
	112	Polk	1.35	Concrete, brick, or asphalt	Dec. 22	39,204.00	19,502.00
Mississippi	11	Amite		Gravel	Dec. 12	[3] 10,721.26	[3] 8,979.00
Missouri	15	New Madrid	19.50	....do	Dec. 23	191,098.16	95,549.08
Montana	34	Yellowstone		Bridge	Dec. 16	195,477.25	97,738.62
Nebraska	37	Sherman	12.05	Earth and sand-clay	Dec. 10	83,585.43	41,792.71
New Hampshire	27	Grafton and Hillsborough	1.46		..do	30,001.18	15,000.59
	31	Grafton	.47	Gravel	..do	5,417.06	2,708.53
	39	....do	.73	....do	..do	10,077.59	5,038.79
	42	Strafford	1.38	....do	..do	12,719.96	6,359.98
	47	Merrimack and Sullivan	1.14	....do	..do	17,193.66	8,596.83
	56	Cheshire	.71	....do	..do	10,587.06	5,293.53
	60	....do	1.34	....do	..do	20,333.17	10,166.58
	76	Hillsborough	1.12	....do	..do	17,101.48	8,550.74
	78	Rockingham	1.444	....do	..do	11,896.11	5,948.05
	82	Merrimack	.475	....do	Dec. 8	9,437.06	4,718.53
	86	....do	.673	....do	Dec. 10	7,623.66	2,811.83
	87	....do	.54	....do	..do	10,174.34	5,087.17
North Carolina	51	Guilford	2.26	Asphalt or concrete	Dec. 26	66,801.92	33,400.96
	53	Lenoir	7.234	Concrete	Dec. 10	254,789.12	127,394.56
	55A	Mecklenburg	6.004	Bituminous	Dec. 23	146,205.60	73,102.80
North Dakota	30	Divide	10.46	Earth	..do	31,739.22	15,869.61
Ohio	54	Mercer	1.673	Concrete	Dec. 3	54,500.00	16,000.00
	62	Morrow	2.553	Bituminous or concrete	Dec. 12	91,000.00	40,000.00
	67F	Logan	3.05	Concrete	..do	123,500.00	52,100.00
	68Q	Perry	1.78	Bituminous or concrete	..do	51,200.00	25,300.00
	91	Wood	6.741	Bituminous	..do	148,800.00	37,700.00
	97	Noble	9.462	Concrete or macadam	..do	220,000.00	67,100.00
	105	Lucas	3.503	Concrete	Dec. 27	95,000.00	47,500.00
Pennsylvania	8H	Erie	3.488	Cement concrete or bituminous concrete on concrete base.	Dec. 20	159,633.30	69,760.00
Texas	14	Montague	41.616	Gravel	Dec. 12	293,635.51	135,000.00
	66	Coural		Bituminous, gravel or macadam	Dec. 10	[3] 31,232.76	[3] 22,809.76
	79	Caldwell	6.67	Gravel	Dec. 12	10,250.25	5,125.12
West Virginia	38	Fayette	5.904	Bituminous	Dec. 10	91,587.35	44,000.00
	42	Raleigh	5.142	....do	Dec. 12	53,350.00	26,675.00
	59	Jackson	.99	Concrete	..do	34,700.00	17,350.00
	63	Morgan	1.36	Bituminous or concrete	Dec. 4	42,000.00	21,000.00
Wisconsin	97	Sauk	6.72	Gravel	Dec. 26	81,000.00	27,000.00
Total	63		354.96			7,374,590.58	3,412,467.71

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[1] 9 sections.

[2] 6 sections.

[3] Modified agreement. Amounts given are increases over those in previous agreement signed.

FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR JANUARY, 1920.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project statement approved	Estimated cost.	Federal aid.
Alabama	73	Choctaw	6.31	Topsoil sand-clay	Jan. 4–6	$46,172.21	$23,086.10
Arizona	23	Pinal	32.70	Caliche gravel	Jan. 27	381,264.40	190,632.20
Arkansas	67	Dallas	21.13	Macadam	Jan. 9	70,549.32	30,000.00
	47	Crittenden	15.75	Gravel macadam	Jan. 17	181,589.32	55,000.00
California	40	Shasta	16.84	Earth	Jan. 9	155,650.00	77,825.00
	42	Tehama	15.17	Concrete	Jan. 23	319,137.50	159,568.75
	43	Mariposa	1.28	Earth	Jan. 29	41,206.00	20,603.00
Colorado	38	Morgan	2.727	Concrete	Jan. 9	102,677.71	51,338.85
	32	Adams	6.002	do	Jan. 23	229,194.35	114,597.17
	23	Delta	5.86		Jan. 29	48,143.42	24,071.71
Florida	23	Duval	12.766	Concrete	Jan. 12	344,035.06	172,017.53
	20	Washington, Holmes		Bridge	Jan. 13	102,872.00	51,436.00
	21	Baker	5.711	Concrete	Jan. 15	183,841.68	91,920.84
	22	do	8.888	do	do	226,898.43	113,449.21
	24	Columbia	9.89	do	Jan. 31	255,253.35	127,626.67
Georgia	117	Gwinnett	8.00	Topsoil	Jan. 9	61,454.80	25,000.00
	128	Barrow	6.909	Sand-clay	Jan. 23	40,000.01	20,000.00
	126	Madison		Bridge	do	40,000.42	20,000.00
	129	Clarke	3.80	Concrete	do	102,992.00	50,000.00
Idaho	32	Clark	10.80	Gravel	Jan. 9	59,998.84	29,999.42
Iowa	49	Emmet	3.95	Pavement	do	154,670.45	77,300.00
	57	Cedar	24.20	Earth	do	85,954.00	42,900.00
	86	Jones	25.20	do	Jan. 12	103,697.00	51,800.00
	64	Jasper	31.50	do	do	136,785.00	68,300.00
	80	Ida	19.50	do	Jan. 5	73,040.00	36,500.00
	87	Muscatine	29.10		Jan. 15	92,653.00	46,300.00
	98	Winneshiek	27.20	Earth	do	149,655.00	74,800.00
	122	Decatur	10.00	do	do	63,607.50	31,800.00
	63	Lucas	23.15	do	Jan. 17	169,125.00	84,500.00
	72	Story	20.50	Gravel	do	84,634.00	42,000.00
	111	Kossuth	22.31	Pavement	do	881,565.96	440,000.00
	78	Woodbury	2.80	do	Jan. 23	120,436.80	56,000.00
	83	Union	24.00	Earth	do	193,842.00	96,900.00
	120	Jefferson	6.90	do	do	45,276.00	22,600.00
	59	Fayette	36.85	do	do	140,646.00	70,300.00
	89	Polk	7.22	Pavement	do	385,832.70	141,400.00
	105	Franklin	9.75	Gravel	do	68,168.37	34,000.00
	115	Cerro Gordo	22.07	Pavement	do	974,098.40	441,400.00
	123	Ringgold	12.00	Earth	do	103,070.00	51,500.00
	23	Marshall	6.00	Brick or concrete	Jan. 20	226,512.00	113,200.00
Kansas	43	Wilson	24.75	Gravel	Jan. 13	601,861.70	147,500.00
	33	Bourbon	12.50	Bituminous macadam	Jan. 15	403,700.00	187,500.00
	41	Atchison	9.38	Brick or concrete	Jan. 23	341,324.50	140,700.00
Kentucky	15	Kenton, Boone	2.109	Concrete		85,789.88	12,180.00
Louisiana	49	Washington	34.97		Jan. 29	421,391.05	210,695.52
	64	Concordia	8.98	Gravel	do	153,898.54	76,949.27
Massachusetts	29	Hampshire	2.626	Bituminous macadam	Jan. 7	93,115.11	46,557.55
	30		4.238		Jan. 31	154,211.24	77,105.62
Michigan	44	Lenawee	22.505	Gravel	Jan. 23	657,800.00	328,900.00
	45	Ingham	5.48	Concrete	Jan. 29	188,815.00	94,407.50
Minnesota	105	Yellow Medicine	12.32	Gravel	Jan. 6	52,439.20	26,210.60
	104	Renville	3.60	Concrete	Jan. 9	137,772.80	41,331.84
	116	Sibley	1.08	Gravel	Jan. 12	45,440.56	13,632.17
	95	Chisago	19.13	do	Jan. 14	362,903.20	181,451.60
	103	Renville	3.84	Concrete brick, and asphaltic	do	148,666.32	44,599.90
	107	Watonwan	14.02	Pavement	do	473,360.80	142,008.24
	122	Chippewa	12.40	Gravel	Jan. 15	91,319.69	27,395.91
	110	Redwood	10.75	do	Jan. 17	38,390.00	19,195.00
	118	Carver	19.43	do	Jan. 15	154,336.60	46,300.98
	126	Rice	3.76	Concrete, brick, and asphaltic	Jan. 17	169,253.48	50,776.04
	134	Jackson	6.00	do	Jan. 19	229,328.00	68,798.40
	125	Wabasha	2.00	Gravel	Jan. 23	56,292.50	16,887.75
	128	Chippewa	15.00	do	do	123,200.00	36,960.00
	127	Stevens	17.46	do	Jan. 28	128,846.30	38,653.89
	123	Carlton	23.14	do	Jan. 29	139,299.60	69,649.80
	132	Becker	9.89	do	do	65,937.46	32,968.73
	117	Mahnomen	22.35	do	Jan. 31	124,553.00	62,276.50
	121	Freeborn	10.10	do	do	94,336.50	47,168.25
	138	Fillmore	4.34	do	do	41,043.20	20,521.60
Missouri	77	St. Louis	15.75	Concrete	do	685,321.34	326,000.00
	78	do	6.08		do	308,123.42	129,850.00
	80	do	7.06	Concrete	do	305,401.97	147,250.00
	79	do	12.634	Asphaltic concrete, brick, concrete	do	573,585.85	255,980.00
	57	Gentry	10.46	Gravel	Jan. 7	210,946.78	105,473.39
	49	Buchanan	20.40	Concrete	Jan. 12	815,767.92	407,883.96
	55	Lewis	5.50	Gravel	do	54,999.56	27,499.78
	60	do	5.70	do	do	62,691.64	31,345.82
	62	Marion	10.50	do	do	64,543.50	32,271.75
	66	Ralls	13.00	do	do	51,480.00	25,740.00
	67	do	7.00	do	Jan. 13	27,720.00	13,860.00
	68	Lewis	4.25	do	do	44,653.84	22,326.92
	69	Hickory	6.70	do	do	36,247.00	18,123.50
	72	do	8.10	do	do	56,140.70	28,070.35
	76	Lewis	6.70	do	do	68,016.08	34,008.04
	64	Ralls	7.00	do	do	27,720.00	13,860.00
	65	do	5.50	do	do	21,780.00	10,890.00
	61	Jackson	2.10	Earth	Jan. 16	127,798.60	52,000.00
	75	Taney	11.03	Gravel	Jan. 23	20,344.26	10,172.13
	71	do	1.83	do	do	13,019.17	6,509.58
	63	Ralls	4.50	do	do	17,820.00	8,910.00
	70	Taney	2.27	do	do	10,489.74	5,244.87
	73	do	2.25	do	Jan. 31	4,845.46	2,422.73
Montana	64	Cascade	18.00	do	Jan. 12	103,961.00	51,980.50
	67	Toole	5.00	do	Jan. 9	41,866.00	20,933.00
	68	Deer Lodge	9.50	Concrete	do	316,525.00	158,262.50
	73	Cascade	10.50	Gravel	Jan. 23	78,760.00	39,380.00
	44	Gallatin	4.50	Hard surface pavement	Jan. 29	130,565.60	65,282.80
	72	Cascade		Concrete	do	25,300.00	12,650.00
	56	Park	12.00	Gravel	do	52,250.00	26,125.00
	70	Silver Bow	12.50	Concrete	do	398,739.00	199,369.50
Nebraska	138	Sappy	8.60	Earth	do	31,020.00	15,510.00
New Jersey	23	Mercer	.626	Concrete	Jan. 5	47,295.38	12,520.00
	21	Morris	6.592	do	Jan. 7	597,917.23	156,840.00
	24	Cape May	5.178	do	Jan. 9	206,879.17	103,439.58
	22	Mercer	.928	do	Jan. 12	84,229.48	18,560.00
New Mexico	40	Otero	6.50	Caliche	Jan. 9	15,031.50	7,515.75
	46	Santa Fe	.572	Gravel	Jan. 23	9,481.40	4,740.70
	42	Socorro	17.20	do	Jan. 29	72,210.60	36,105.30

FEDERAL AID, PROJECT STATEMENTS APPROVED, FOR JANUARY, 1920—Continued.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
New York	38	Sullivan, Ulster	11.50	Concrete	Jan. 9	$460,000.00	$230,000.00
	39	Tioga	7.60	do	Jan. 12	304,000.00	152,000.00
	35	Jefferson	8.50	do	Jan. 16	340,000.00	170,000.00
	37	do	2.60	do	do	104,000.00	52,000.00
	42	Delaware	5.75	do	do	230,000.00	115,000.00
	43	Clinton	8.10	Reinforced concrete	do	324,000.00	162,000.00
North Carolina	105	Hoke	10.00	Sand-clay	Jan. 7	81,363.33	40,681.66
	81	Pender	27.20	Topsoil	Jan. 9	187,296.56	93,648.28
	102	Harnett	21.00	Clay-gravel	do	181,368.00	90,684.00
	103	Duplin	11.66	Sand-clay	do	37,644.75	18,822.37
	104	Chowan	20.50	Concrete	do	426,426.00	213,213.00
	106	Alamance	18.00	Topsoil, bituminous macadam	do	230,639.64	115,319.82
	109	Burke	3.60	Topsoil	do	42,149.25	21,074.62
	110	Orange	3.80		Jan. 12	151,946.85	75,973.42
	112	Caswell	11.60	Topsoil	Jan. 9	93,434.00	46,717.00
	57	Rowan	7.60	do	Jan. 23	85,140.66	42,570.33
	61	New Hanover, Brunswick	2.31	Concrete	do	193,248.55	79,500.00
	113	Caswell	17.60	Topsoil	Jan. 27	136,433.00	68,216.50
	111	Forsyth	13.50	do	Jan. 29	72,281.00	36,140.50
North Dakota	57	McLean	10.00	Earth	Jan. 14	33,000.00	16,500.00
	100	Burleigh		Bridge	Jan. 19	750,000.00	375,000.00
	92	Foster	4.00	Earth	Jan. 27	13,288.00	6,644.00
	95	Ramsey	12.50	Gravel	do	56,650.00	28,325.00
	103	Eddy	4.00	do	do	22,880.00	11,440.00
Oklahoma	24	Garfield	9.393	Concrete	Jan. 7	400,000.00	200,000.00
	21	McIntosh	7.151	Gravel	Jan. 12	142,277.16	61,509.17
	27	Kay	2.00	Brick concrete	Jan. 29	68,600.38	34,300.19
Oregon	36	Wasco	7.76	Earth	Jan. 12	101,557.50	50,778.75
	35	do	9.02	do	do	317,380.25	158,690.12
Rhode Island	7	Newport	2.57	Bituminous macadam	Jan. 5	109,115.38	51,400.00
	8	Kent	4.40	Concrete	Jan. 23	242,000.88	88,000.00
South Carolina	28	Orangeburg	20.34	do	Jan. 14	351,986.63	70,000.00
	55	Greenwood	18.239	do	Jan. 23	214,185.62	20,422.10
	48	Georgetown	16.849	Sand-clay	Jan. 29	146,227.29	73,113.64
South Dakota	25	Brookings	12.00	Gravel	Jan. 15	92,279.00	46,139.50
	36	Turner	17.45	do	Jan. 14	158,985.75	79,492.87
	39	Davison	15.70	do	Jan. 17	114,903.80	57,451.90
	40	McCook	17.55	do	do	128,440.40	64,220.20
	42	Brown	21.00	do	do	182,567.00	91,283.50
	43	Hutchinson	18.95	do	do	149,635.20	74,817.60
Texas	120	Cass	12.634	do	Jan. 9	104,813.63	25,000.00
	124	Hill	14.90	do	Jan. 15	224,134.90	51,000.00
	130	Kaufman	16.09	Gravel, bituminous top	Jan. 9	172,000.00	62,000.00
	106	Brazoria	9.44	Shell	Jan. 29	156,679.57	39,169.89
Washington	49	King	4.84	Concrete	Jan. 31	187,983.18	90,000.00
West Virginia	84	Preston	3.50	Bituminous macadam	Jan. 29	63,680.00	31,680.00
Wisconsin	107	Monroe	.88	Concrete	do	24,000.00	8,066.67
	123	Manistowoc	3.88	do	do	132,000.00	44,650.00
	153	Eau Claire	.445	do	do	17,384.00	5,800.00
	135	Buffalo	2.11	do	do	66,000 00	22,400.00
	136	Vernon	2.88	do	do	90,000.00	31,100.00
Wyoming	63	Park	6.084	Sand-clay	do	53,790.00	26,895.00
	65	Big Horn	3.582	do	do	31,790.00	15,895.00
	57	Converse	3.562	do	do	113,795.00	56,897.50
Total	162		1,715.82			27,771,696.53	12,452,426.66

FEDERAL AID, PROJECT AGREEMENTS SIGNED, FOR JANUARY, 1920.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	34	Montgomery		Bridge	Jan. 6	$83,564.47	$41,782.23
	50	Coffee	6.41	Sand clay	Jan. 17	29,006.91	14,503.45
	53	Coosa	3.17	Earth	do	21,850.46	10,925.23
	54	do	1.48	do	do	12,103.48	6,051.74
	58	Jefferson	3.19	do	Jan. 23	53,529.13	26,764.56
	55	do	5.013	Pavement	Jan. 29	190,332.02	95,166.01
	40	Marshall	5.60	Macadam	do	49,921.19	24,960.59
	56	Jefferson	3.82	Pavement	do	162,815.58	74,400.00
	47	Butler	3.37	Sand, clay, or top soil	do	32,961.02	16,480.51
Arkansas	32	Hempstead	8.07	Clay-bound gravel	Jan. 17	76,823.01	25,000.00
	33	Cross	4.74	Gravel macadam	do	41,492.70	12,500.00
California	31	Del Norte	4.08	Gravel	do	37,136.70	18,568.35
	18	Humboldt	7.43	Concrete	do	151,646.96	75,823.48
Colorado	21	Otero	.407	do	Jan. 12	16,047.62	8,023.81
	61	do	.407	do	do	16,014.62	8,007.31
	27	Mesa	.265	do	Jan. 29	10,801.14	5,400.00
Delaware	7	New Castle	2.01	do	Jan. 17	147,950.55	40,020.00
Georgia	39	Laurens		Bridge	Jan. 6	187,333.74	93,666.87
	68	Walton	9.13	Top soil	do	86,590.35	43,295.17
	76	Wheeler	9.87	Sand clay	do	96,985.13	48,492.56
	41	Douglas	6.572	Top soil	Jan. 12	40,803.[illegible]	20,000.00
	66	McDuffie	.677	Sand clay	do	12,004.39	6,002.19
	100	Terrell	13.549	do	do	80,082.83	25,000.00
	98	Troup	5.53	do	Jan. 29	70,663.70	30,331.85
Idaho	13	Owyhee		Bridge	Jan. 6	89,980.00	44,990.00
Illinois	3	Will	16.374	Concrete	do	507,128.05	253,564.02
	4	Lake	19.032	do	do	757,0[illegible]	[illegible].17
	7	Marshall	32.613	do	do	1,301,8[illegible]	599,770.19
	[1] 9		32.625		Jan. 17	1,443,422.27	711,479.12
Iowa	29	Wright	14.67	Gravel	Jan. 9	161,640.32	80,800.00
	46	Pottawattamie	2.65	Earth	Jan. 5	[illegible],819.65	13,400.00
	54	Scott	8.46	Brick or concrete	Jan. 6	[illegible]	[illegible],000.00
	41	Floyd	12.40	Gravel	Jan. 23	504,[illegible]	[illegible]
Kansas	26A	Rice	2.301	Concrete or brick	Jan. 29	[illegible]	34,515.00
	37AB	Montgomery	3.362	Gravel	do	75,838.00	37,919.00
	23	do	9.876	do	do	139,171.80	69,585.90
	16A	Rice	3.043	Brick or concrete	do	166,[illegible]	[illegible]15.00

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[1] 10 sections.

FEDERAL AID, PROJECT STATEMENT APPROVED, FOR JANUARY, 1920—Continued.

State.	No. of project.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Louisiana	46	Red River	8.05	Sand clay, gravel	Jan. 17	$77,018.01	$38,524.00
Maine	4	Penobscot	7.05	Gravel	Jan. 12	106,318.52	53,159.26
Maryland	27	Baltimore	.914	Concrete	Jan. 15	84,365.49	18,288.00
	37A	Kent, Queen Anne	2.00	do	do	61,183.54	30,591.77
	25A	Charles	3.00	Gravel	do	42,672.19	21,336.09
Massachusetts	23	Berkshire	2.124	Concrete	Jan. 6	63,147.75	31,573.87
	26	Franklin	5.134	do	do	279,677.36	102,680.00
	15	Plymouth	4.38	do	do	122,338.70	61,169.35
Minnesota	52	Itasca	8.83	Gravel	Jan. 5	51,409.76	25,000.00
	67	Pennington	3.70		Jan. 6	22,781.55	11,390.77
	85	Cottonwood	5.42		do	36,285.94	17,000.00
	88	Chippewa	5.01	Gravel	do	51,560.77	25,000.00
	62	Dodge	13.20	do	Jan. 31	53,075.57	26,537.78
Mississippi	77	Jackson	2.64		Jan. 12	100,544.73	50,272.36
	40	Monroe	13.965	Gravel	Jan. 29	130,487.69	65,243.84
	44	Lawrence	10.68	Clay gravel	do	49,923.96	24,961.98
Montana	10	Cascade	18.690	Screened gravel	Jan. 6	92,925.96	46,462.98
	23	Blaine	4.25	Gravel	Jan. 29	24,192.96	12,096.48
	16	Rosebud	3.84	do	Jan. 31	21,987.08	10,993.54
	41	Gallatin	5.00	do	do	51,826.52	25,913.26
Nebraska	39	Dawson	27.47	Earth	Jan. 6	110,139.74	55,069.87
	40	Thayer	7.27	Gravel clay	Jan. 17	30,741.37	15,370.68
	74A	Dundy	4.49	Earth	do	27,826.04	13,913.02
	51	Kearney, Franklin	16.19	do	do	61,256.56	30,628.28
	11	Gosper	7.05	do	Jan. 28	38,815.53	19,407.71
Nevada	17	Lyon	5.89	Gravel	Jan. 17	46,310.11	23,155.05
	24A	Churchill	10.42	Gravel, crushed rock	do	104,500.00	52,250.00
New Hampshire	84	Grafton		Bridge	Jan. 6	17,381.21	8,690.60
	85	Merrimack	.473	Gravel	do	4,014.50	2,007.25
	30	Grafton	.427	do	do	5,114.89	2,557.44
	73	Carroll	.785	do	do	14,160.96	7,080.48
	74	do	1.27	W. B. macadam	do	19,319.30	9,659.65
	34		.549		do	4,929.81	2,464.90
	44	Cheshire	.317	Bituminous macadam	do	12,351.88	6,175.94
	48	do	.24	Gravel	do	20,971.91	9,691.22
	57	do	.539	do	do	12,852.73	6,426.36
	61	do	1.63	do	do	21,192.60	10,596.30
	62	Strafford	.68	do	do	8,158.53	4,079.26
	66	Carroll	1.03	do	do	9,338.39	4,669.19
	72	Merrimack	1.07	do	do	15,174.06	7,587.03
	81	Grafton		Bridge	do	11,964.20	5,982.10
	73	do	3.106	Gravel	Jan. 29	44,692.34	22,346.17
	58	do	1.136	do	do	29,840.91	14,920.45
	49	Belknap	1.09	do	do	9,343.40	4,671.70
New Jersey	15	Middlesex, Union	3.55	Concrete	Jan. 5	142,119.23	71,059.61
	16	Hunterdon	2.137	do	Jan. 6	233,711.12	42,740.00
North Carolina	63	Buncombe	3.68	Macadam	Jan. 29	133,545.32	66,772.66
	76	Cabarrus	1.35	Concrete base; bituminous surface	do	48,633.20	24,316.60
	79	Cleveland	1.645	Concrete or bituminous macadam	Jan. 26	67,063.64	32,900.00
	64	Carteret	13.67	Concrete	Jan. 31	342,497.74	171,248.87
North Dakota	45	Foster	11.10	Earth	Jan. 12	40,289.22	20,144.61
	44	Bottineau	4.51	do	Jan. 5	32,257.65	16,128.82
	34	Emmons	11.69	Grading and draining	Jan. 17	44,767.86	22,383.93
	28	Ransom	17.895	do	Jan. 29	58,547.39	29,273.69
Ohio	39	Auglaize	7.815	Concrete	Jan. 5	282,000.00	70,500.00
	29	Scioto	6.639	Concrete or brick bituminous	Jan. 6	262,000.00	69,000.00
	83	Cuyahoga	9.749	Concrete	Jan. 5	163,349.62	81,000.00
	95	Paulding	2.997	Brick or concrete	Jan. 29	114,450.00	30,000.00
	101	Adams	6.254	W. B. macadam	do	119,000.00	48,000.00
Oklahoma	10	LeFlore		Bridge	Jan. 12	107,919.43	53,959.71
	13	Pushmataha		do	Jan. 29	12,156.92	6,078.46
	11	Pottawatomie		do	Jan. 31	198,467.79	99,233.89
Oregon	4	Wheeler	9.47	Earth	Jan. 12	55,449.90	27,724.95
	28	Malheur	9.11	Gravel	Jan. 31	73,930.17	36,965.08
South Carolina	21	Edgefield	8.42	Topsoil	Jan. 5	65,077.73	32,538.86
	27	Spartanburg	3.676	do	Jan. 6	34,732.21	17,366.10
	29A	Laurens	14.316	do	Jan. 5	100,149.12	50,074.56
	30	Pickens	5.708	do	Jan. 6	56,793.27	28,396.63
	31	Spartanburg	1.989	Asphalt on concrete base	Jan. 5	57,749.92	28,874.96
	20	Cherokee	9.095	Topsoil	Jan. ..	48,102.28	24,051.14
South Dakota	16	Hughes	17.83	Earth-gravel	Jan. 12	74,476.34	37,238.17
	17	Lake	12.44	Gravel	Jan. 9	115,566.03	57,783.01
	18	Hand	15.03	do	do	140,765.29	70,382.64
	19	Hyde	6.96	do	Jan. 6	66,562.95	33,281.47
	21	Aurora	7.76	do	Jan. 9	69,166.16	34,583.08
Tennessee	8	Shelby	16.04	Bituminous macadam	Jan. 28	361,563.56	180,781.78
Texas	59	Calhoun	10.312	Mud-shell-bituminous surface	Jan. 5	31,679.19	15,804.00
	74	Travis	3.89	Gravel—bituminous surface	Jan. 17	11,429.28	5,714.64
	101	Bowie	14.78	Gravel	Jan. 29	117,168.46	58,584.23
	97	Brazos	10.33	Gravel concrete	Jan. 31	112,950.04	42,752.75
	98	Collin	24.955	Concrete and gravel—bituminous top	do	330,120.91	135,000.00
Utah	4A & B	Emery and Carbon	.37	Grading and draining	Jan. 30	16,407.96	8,203.98
Virginia	53	Fauquier	3.105	W. B. macadam	Jan. 6	62,807.58	31,403.79
	32	Fairfax	3.274	Bituminous macadam	do	64,125.60	32,062.80
	40	Dinwiddie	1.622	Concrete	Jan. 5	41,282.06	20,641.03
	51	Loudoun	4.45	W. B. macadam	Jan. 31	71,353.21	35,676.60
	57	Pulaski	4.07	do	Jan. 29	58,668.06	29,334.03
Washington	44	Clarke	4.03	Concrete	Jan. 17	157,161.30	60,000.00
	45	Chelan	2.155	Gravel	do	91,037.10	43,100.00
West Virginia	67	Berkeley	7.03	Bituminous macadam	Jan. 6	82,840.00	41,420.00
	32	Roane	3.75	Concrete	do	127,294.91	44,104.00
	80	Marshall	.484	Brick on concrete base	do	23,700.00	9,680.00
	17	Brooke	1.00	Brick and bituminous macadam	Jan. 12	40,130.00	7,580.00
	64	Jefferson	5.56	Bituminous macadam	Jan. 29	77,390.00	38,695.00
	76	Brooks	1.00	Bituminous macadam and concrete	do	25,800.00	12,900.00
	79	Pocahontas	5.53	Bituminous macadam, earth	Jan. 26	84,370.00	42,185.00
	73	Mineral	10.486	Gravel	Jan. 31	71,534.00	35,744.00
Wisconsin	45	Ashland	7.931	Earth	Jan. 6	38,998.76	12,999.59
	100	Grant	1.135	do	Jan. 5	27,000.00	9,000.00
	87	Buffalo	3.45	do	Jan. 29	50,787.91	16,929.30
	94	Marathon	4.23	Concrete	do	121,250.85	40,416.95
	95	Milwaukee	1.04	Bridge	do	67,647.14	22,549.04
	52	La Crosse	1.39	Bituminous macadam	do	18,007.50	6,002.50
Total	110		867.05			15,335,788.45	6,947,170.49

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BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 23 WASHINGTON, D. C. MARCH, 1920

VIEW ON COLUMBIA RIVER HIGHWAY, SHOWING ATTRACTIVE AND SUBSTANTIAL GUARD RAIL

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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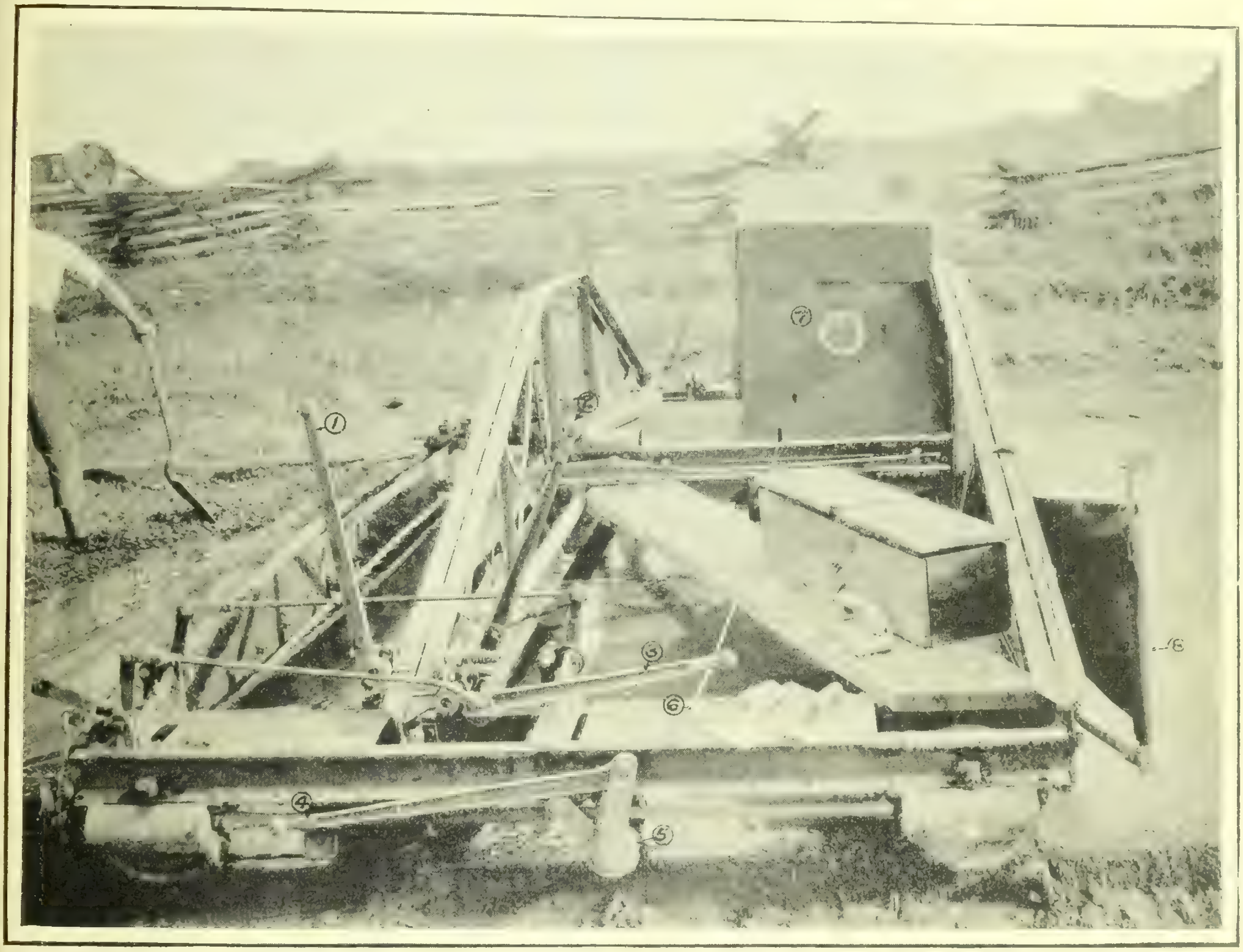
MECHANICAL CONCRETE ROAD FINISHER

By H. G. McKELVEY, Senior Highway Engineer, U. S. Bureau of Public Roads.



THE CONCRETE ROAD FINISHER. 1. FORWARD AND REVERSE LEVER. 2. TAMPING LEVER THAT OPERATES THE TAMPING BOARD SHOWN AT THE FRONT OF THE MACHINE. 3. STRIKE-OFF LEVER. 4. LEVER OPERATING ADJUSTING ROLLER, 5, BY MEANS OF WHICH ONE SIDE OF THE MACHINE IS PREVENTED FROM GETTING TOO FAR AHEAD OF THE OTHER. 6. THROTTLE LEVER LEADING FROM THE 4 H. P. AIR-COOLED NEW WAY ENGINE IN THE HOUSING CASE 7. 8. FINISHING BELT SHOWN RAISED, WHICH OPERATES AUTOMATICALLY WHEN LOWERED. THE MACHINE HAS THE SAME NUMBER OF LEVERS ON EACH SIDE AND CAN BE OPERATED FROM EITHER.

THE scarcity and high cost of labor during the past two years or more have seriously handicapped highway construction generally, but have been beneficial to the extent that they have resulted in the invention of a number of labor-saving devices which offset, to some extent, the perplexing labor problems.

One notable instance of this development is a machine which automatically strikes, consolidates, and floats concrete pavements and forms monolithic brick surfaces, with the aid of but one man for its operation for either type of pavement.

The concrete road finisher, shown in the illustration was primarily devised for concrete pavement construction, but is equally well adapted to the preparation of the concrete base for monolithic brick construction, and the tamping and shaping of the brick surface. The machine, sustained on the four flanged wheels, travels on the ordinary side forms used to confine the concrete or brick and is moved forward or backward under its own power, operating during the forward movement but usually running idle in the reverse direction. The power, for both traction and operation, is furnished by a 4-horsepower, air-cooled, gasoline engine, protected by a housing.

The three principal members of the machine operate during the manipulation of the material for a concrete pavement. They are, (1) a striking template with a metal edge, adjustable to the crown of the pavement; (2) a tamper, consisting of a heavy timber, kiln-dried and oil-soaked, and shod with a

A MIXTURE OF THE PROPER CONSISTENCY. THE MACHINE PERMITS THE USE OF DRIER MIXTURES THAN CAN BE WORKED BY HAND METHODS.

steel channel; and (3) a finishing belt attached to a supporting frame at the rear of the machine. These three parts have distinct functions to perform and operate simultaneously or separately as occasion requires. The cutting template strikes off the concrete, roughly spread by two men as it is deposited from the mixer, and shapes it to the approximate height and crown desired. The tamping device consolidates the concrete with well directed, quick blows to the required cross section: and the finishing belt floats the surface to a smooth finish, operating slowly with a sidewise motion as the machine advances.

The details of the machine can be understood by turning to the illustration, in which the various parts are numbered for purposes of identification. The direction of motion is controlled by the lever marked (1), (2) is a lever which raises or lowers the tamper shown at the front of the machine, (3) is a lever which operates the striking template, shown in action in figure 2, the lever marked (4) raises or lowers the roller (5). This device prevents one side of the machine from advancing beyond the other. When this occurs, the roller is lowered into contact with the form, lifting the wheels from the form on one side, and thus permitting those on the other side to catch up. The operation of the engine in the housing (7) is controlled by the throttle lever (6); and (8) is the finishing belt in the raised position. Released for action the belt is lowered and operates automatically with a sidewise motion. The machine has the same number of levers on each side, and can therefore be operated from either with equal facility.

This device is manufactured for use on pavements of several widths, but is not adjustable so that the same machine can be used on pavements of different widths. The net weight is 2,600 pounds.

TAMPER STRIKES UNIFORM BLOW.

The principal benefit is derived from the action of the tamper. The device replaces the usual heavy timber tamper, which is laboriously operated by two or four men. The machine tamper strikes a uniform blow over the entire width of the pavement. By its use the consolidation is effected usually by three passages over the surface, the first time striking a long, hard blow, and the second and third times delivering short, rapid strokes. The nature of the blow is within the control of the operator.

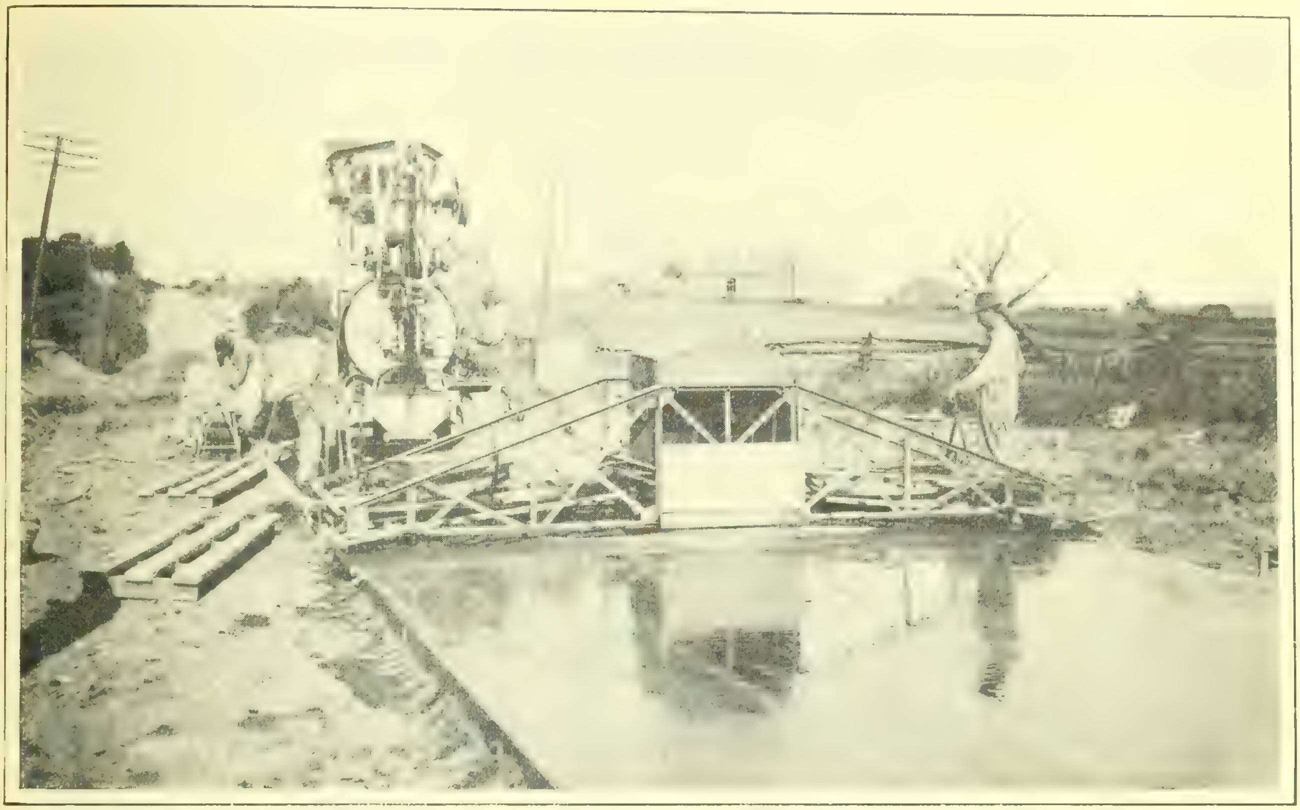
The striking member is adjustable to operate or remain idle, as occasion requires, as is also the belting contrivance. During the first and second transit over the mixture the cutting template is in place, but the belt is elevated and remains idle. The third time over the tamping device only is permitted to operate. For the fourth and last operation the tamper is adjusted to strike about 150 blows to the minute, and the belt is lowered into place, completing the work. During the forward movement the machine travels at a speed of 7 feet per minute, and in reverse it travels 30 feet per minute.

Experiments have proved that a comparatively dry mixture will produce stronger concrete than one in which an excessive amount of water is use, but the practical difficulty of consolidating and finishing dry mixtures by hand methods has stood in the way of the general employment of such mixtures. This machine permits the use of drier mixtures than could be worked by hand methods and its use should result in the production of concrete that will set quicker, form slabs of greater strength, and pavements that will be ready for service in shorter time.

ADVANTAGE IN USING DRY MIXTURES.

The machine is not effective in finishing wet concrete. It produces a wavy surface, as shown on page 5. However, this is not a defect, but rather one of the greatest advantages of the machine, for it soon becomes evident to all who are employed at the mixer that to obtain workable concrete a dry mixture must be furnished. The inspector is thus relieved of the trouble which has always been experienced in securing dry mixtures by hand methods, due to the greater effort required by such methods to manipulate the dry concrete.

On the whole this machine represents a long stride forward in the construction of concrete roads, but it is not without defects, some of which are serious.



THE MACHINE IS NOT EFFECTIVE WITH WET CONCRETE. WAVY SURFACE PRODUCED BY THE MACHINE IN FINISHING WET CONCRETE.

For example, as previously stated, each machine can be used on only one width of pavement. If, therefore, a contractor would equip himself to construct all of the widths which are specified by the different States, counties, or municipalities for which he performs work, he must have at least as many tampers as there are widths specified; and as the factory price is $1,650, such an outfit might call for a very considerable investment.

To support the great weight of the machine, forms must be given better support than they commonly are and must be rigidly secured laterally. The additional expense of this work detracts from the saving in the operations performed by the machine. But the most serious fault is that the machine can not be used in developing changing cross sections, such as are used in the superelevation and widening of curves. Sections of surface which lie on such curves must still be consolidated and finished by hand, and this fault leads to a lack of uniformity in the character of the surface of the road as a whole.

MORE BONDS.

By a vote of 800 to 63 the citizens of the Lompoc road district, in Santa Clara County, Calif., have decided in favor of a bond issue of $400,000 for the construction of improved roads.

IOWA HIGHWAYS.

Of the 99 counties in Iowa, all but 1 have adopted a definite program of highway improvement. Twelve counties have voted bond issues, the aggregate amounting to nearly $28,000,000, for permanently graded, hard-surfaced roads, which will be used with Federal-aid funds and the funds available from other sources. A great many other counties have voted for hard-surfaced roads, to be built from regular taxation.

ISSUE OF BONDS LEGAL.

The Supreme Court of Washington has decided that the plan adopted by the commissioners of Spokane County for the issuing of bonds to the amount of $3,250,000 recently voted by the people complies with the election. The point at issue was the question of the retirement of the bonds. The method adopted by the commissioners would not permit the retirement of some of the securities until about 23 years after the bonds had been legalized by the election, which was based on a 20-year issue. The attorney general had held that the method adopted did not comply with the election proposition and the State auditor had refused to pay over to the commissioners $450,000, the first issue to be sold.

A CONVENIENT METHOD OF COMPUTING CROSS SECTIONS

By G. T. McNAB, Senior Highway Engineer, U. S. Bureau of Public Roads.

ONE of the most monotonous details of a field engineer's work is the computation of cross sections. Various methods have been devised for performing this work, but all of them are open to the criticism that they are laborious in the extreme. So far as the writer knows, this applies whether they involve the calculation of the areas of cross sections by ordinary mathematical methods or whether they involve the plotting of the cross sections and the measurement of their areas by planimeter. Therefore any new method designed to simplify this work should be of interest to field engineers generally.

The method outlined below is more convenient than any of which the writer knows. As the discussion proceeds those who are familiar with the various systems of land measurement will probably recognize it as the method of computing land areas by latitudes and double meridian distances. Its value for the computation of cross sections is not generally recognized. The time required to compute cross sections by this process is remarkably short, and by the use of it the volume of work that can be done in a day is correspondingly large, so whether the method is absolutely new or not, it is worthy of much more general adoption. This method is much simpler than any other of which the writer knows and can be used in computing the area of the most complicated figures as readily as that of an ordinary cross section. One who is expert in the use of this method finds it a comparatively simple matter to compute the cross sections on as much as 5 or 6 miles of highway in a single working day. The discussion of the method follows.

Let figure 1 represent any cross section, as, for instance, one cross section of a borrow pit. Before any excavation is taken out lines of levels will, of course, be run over the area from which excavation is to be taken. Let it be assumed that the elevations on the first line run, are as follows:

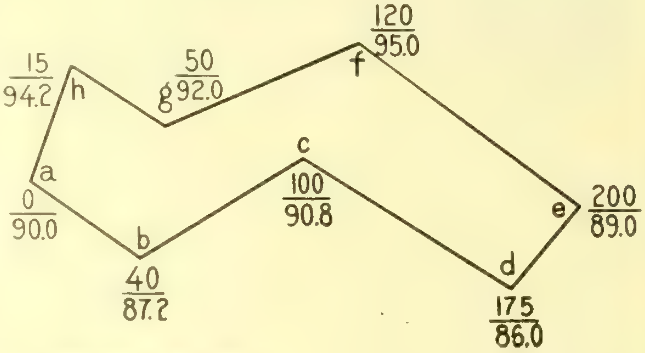
0	15	50	120	200.
90	94.2	92	95	89

Similar elevations would, of course, be taken on the other lines run. And here the first important feature of this system develops. It is a matter of entire indifference, so far as this system of computing cross sections is concerned, as to how far apart the stations are, whether they are equal distances apart or not, or as to whether there is any means provided for reoccupying any of the intermediate stations. The only matter of importance is that the excavation shall fall between the point zero and the last point occupied and that these two points shall be carefully preserved.

After excavation has proceeded for a time new elevations are taken over the course, the following notes resulting:

0	40	100	175	200
90	87.2	90.8	86	89

Again the matter of the selection of the stations between station zero and the last point occupied—in this case 200—is one of entire indifference, for the calculation of the area inclosed between the original line and the new line can be as readily calculated where the intervening stations occupied are different from those selected when the course was run the first time, as when they are the same.



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 (40+100)× 3.6=  504.0          (0+ 40)× 2.8=  112.0
(175+200)× 3.0=1,125.0        (100+175)× 4.8=1,320.0
(200+120)× 6.0=1,920.0        (120+ 50)× 3.0=  510.0
 (50+ 15)× 2.2=  143.0         (15+  0)× 4. 2=   63.0
           ----  -------                ----  -------
           14.8  3,692.0                14.8  2,005.0
                 2,005.0
                 -------
               2)1,687.0
                 -------
                   843.5 Area.
```

FIG. 1.—SHOWING COMPUTATION OF BORROW-PIT AREA.

The two sets of elevations over this course form the figure,

a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*a*
0	40	100	175	200	120	50	15	0
90	87.2	90.8	86	89	95	92	94.2	90

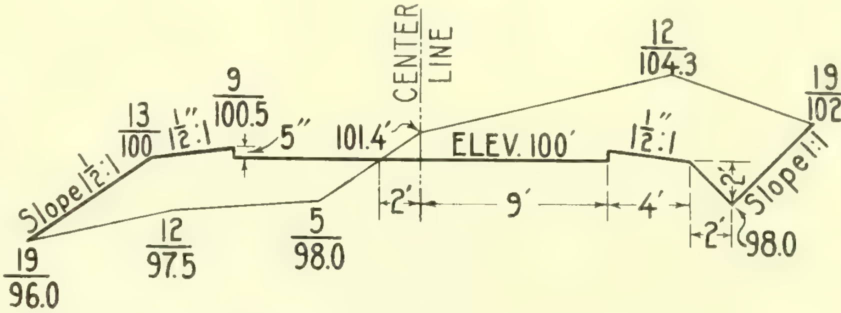
which is a closed figure. The area of this figure may be computed from any point in the series, but for ease in computation and because this is the general procedure, the zero point will be selected.

The area is computed by taking one-half of the algebraic sum of the products resulting from the multiplication of the sum of the horizontal distances from the zero point, assumed, to each end of each of

```
 (0+ 9)×0.0=  0.0            (9+13)×0.5= 11.0
 (9+ 9)×0.5=  9.0           (13+15)×2.0= 56.0
(15+19)×4.0=136.0           (12+ 0)×2.9= 34.8
(19+12)×2.3= 71.3            (0+ 0)×1.4=  0.0
 (2+ 0)×1.4=  2.8            (0+ 2)×0.0=  0.0
            ——  ———          (0+ 0)×1.4=  0.0
            8.2 219.1                   ——  ———
                101.8                   8.2 101.8
                ———
                ———
              2)117.3
                ———
                 58.65 Area.
```

EXCAVATION.
EMBANKMENT.

```
  (0+ 2)×0.0=  0.0          (2+ 5)×2.0=14.0
(19)+13)×4.0=128.0         (5+12)×0.5= 8.5
 (13)+ 9)×0.5= 11.0        (12+19)×1.5=46.5
             ——  ———        (9+ 9)×0.5= 9.0
             4.5 139.0      (0+ 9×)0.0= 0.0
                  78.0      (0+ 9×)0.0= 0.0
                 ———                   ——  ———
               2) 61.0                 4.5 78.0
                 ———
                  30.5 Area.
```



EXCAVATION.

```
(15+)19×4.0=136.0                    2.0
(19+)12×2.3= 71.3       (13+15)×2.0=56.0
 (2+) 0×1.4=  2.8       (12+ 9)×2.9=34.8
             ———                    ———
             210.1                 `92.8
              92.8
             ———
           2)117.3
            e———
              58.65 Area.
```

EMBANKMENT.

```
                  2.0     (2+ 5)×2.0=14.0
(19+13)×4.0=128.0         (5+12)×0.5= 8.5
            ———          (1+19×)1.5=46.5
            130.0                    ———
             69.0                    69.0
            ———
          2) 61.0
            ———
             30.5 Area.
```

FIG. 2.—SHOWING METHOD OF COMPUTING AREAS OF EXCAVATION AND EMBANKMENT IN A SIDEHILL SECTION.

the boundary lines of the cross section by the differences in elevation of the two ends of the respective lines, considering the products derived from descending lines as negative, and those from ascending lines as positive. There, therefore, result two columns of quantities, one a negative column, the other a positive column. Thus, turning to figure 1, we have for line *ab* (0+40)×2.8=112, which is placed in the negative column because elevation 87.2 is less than elevation 90, and therefore this line is a descending line. From station 40 to station 100, which is line *bc*, we have (40+100)×3.6=504, which is placed in the positive column because this line is an ascending line. Descending from station 100 to station 175, we have (100+175)×4.8=1,320, which is placed in the negative column. Then from station 175 to station 200, which is an ascending line, we have in the positive column (175+200)×3=1,125. Returning from station 200 to station 120 we ascend, and therefore place in the positive column (200+120)×6=1,920. Descending to station 50 we place in the negative column (120+50)×3=510. Ascending again from station 50 to station 15 we have (50+15)×2.2=143, to place in the positive column, and finally from station 15 to station 0, the point of beginning, we have (15+0)×4.2=63, which is placed in the negative column because this is a descending line.

As these numbers are set down they are usually written in two columns as shown in figure 1. As a check on the accuracy with which the quantities have been taken off, the multipliers in both columns should be added, and if the differences in elevation have been correctly calculated the sums of the positive and of negative side will be equal. In this case the multipliers total 14.8 on both sides. Adding the products we have 3,692 on the positive side and 2,005 on the negative side, the difference being 1,687. One-half of this is 843½, which is the area of this cross section. It should be clear at a glance that the final result of this process is, as stated above, entirely independent of the number of stations appearing between station 0 and station 200, either in the original survey or in any subsequent survey. It is not necessary that the stations, other than the first and last, have any other relation to each other than that they appear on the same line. From this it should be clear that this method is of particular advantage in cross sectioning borrow pits, as it is not essential that any points be preserved in the area where work is being carried on. Indeed all levels may be taken at the most advantageous points and at those points which will tend to promote the greatest accuracy in the final result, regardless either of preceding or of successive work. This system is, therefore, peculiarly adapted to field conditions. Moreover, owing to the simplicity of the calculations any desired degree of refinement may be secured, for any increase in the number of stations occupied merely serves to increase the number of computations per cross section, but in no way increases their complexity.

Finally, the system is so simple that it can be taught to any one who can add and multiply. This is an important matter, for it enables the chief of party to train his subordinates—even the brighter rodmen and axmen—to compute cross sections quite as accurately as he can do it himself.

The application of the method to the computation of the areas of road cross sections involves processes which are similar to those which have already been described for the calculation of borrow pit areas. In this case, however, it is convenient to assume as the zero or reference point the center of the subgrade. In doing so, however, to avoid negative areas it is necessary to proceed around areas to the right of the center in an anticlockwise direction, and areas to the left in a clockwise direction. When the area is entirely in excavation or entirely in embankment, or when, on side hill sections, an area of excavation or embankment crosses the center of the road, it is necessary to consider the parts to the right and left of the center as separate areas and to bear in mind the injunction as to direction, else the correct area will not be obtained.

Figure 2 illustrates the method of computing the areas of excavation and embankment in a sidehill section. In the computations set down above the figure, it will be observed that the parts of the area of excavation on the right and left of the center, respectively, are considered as separate areas and that the algebraic signs of the partial products are determined by proceeding in the anticlockwise direction around the part to the right and in the clockwise direction around the part to the left of the center. Similarly the area of embankment which lies entirely to the left of the center is encircled in a clockwise direction.

As set down above the figure, the computations are unnecessarily extended by the inclusion of the multiplications, the products of which are zero. In practice, these can be determined by inspection and omitted. A further saving in time and labor results from the recognition of the fact that a constant road cross section yields a constant difference between the positive and negative products which result from progressing from the center reference point to the edge of the shoulder. Thus on the excavation side the products to this point are:

PLUS.	MINUS.
$(0+9)\times 0=0.0$	$(9+13)\times 0.5=11.0$
	11.0
$(9+9)\times 0.5=9.0$	9.0
9.0	Difference −2.0

On the embankment side, beginning at the shoulder and proceeding in a clockwise direction to the center, the products are:

PLUS.	MINUS.
$(13+9)\times 0.5=11.0$	$(9+9)\times 0.5=9.0$
11.0	$(0+9)\times 0=0.0$
9.0	9.0
Difference + 2.0	

The difference is 2.0 in each case, but for areas to the right of the center it has the negative sign and for areas to the left of the center the quantity is positive.

Such a constant may be determined for any given cross section, and thereafter the computation of the areas may be simplified by following the form shown under the cross section in figure 2.

DIRT ROAD EXPERIMENT.

Erie County, Pa., has 11,000 miles of highways. It has planned to construct 90 miles of paved road this year, and for the building of roads has already authorized bonds to the amount of $1,200,000, $500,000 of which were sold last year. By the end of the summer it is estimated that the limit of the county's bonding power, $1,800,000, will have been reached, and it will be necessary to submit a new bond issue to the people in November.

Because of the road situation County Commissioner W. G. Walker advocates the construction of and experimentation with dirt roads, especially for roads which can not be now paved, and has recommended that $54,000 be spent on them this year. He estimated that a well-drained county dirt road can be built at a cost of from $1,000 to $3,000 a mile.

TO INCREASE ROAD FUNDS.

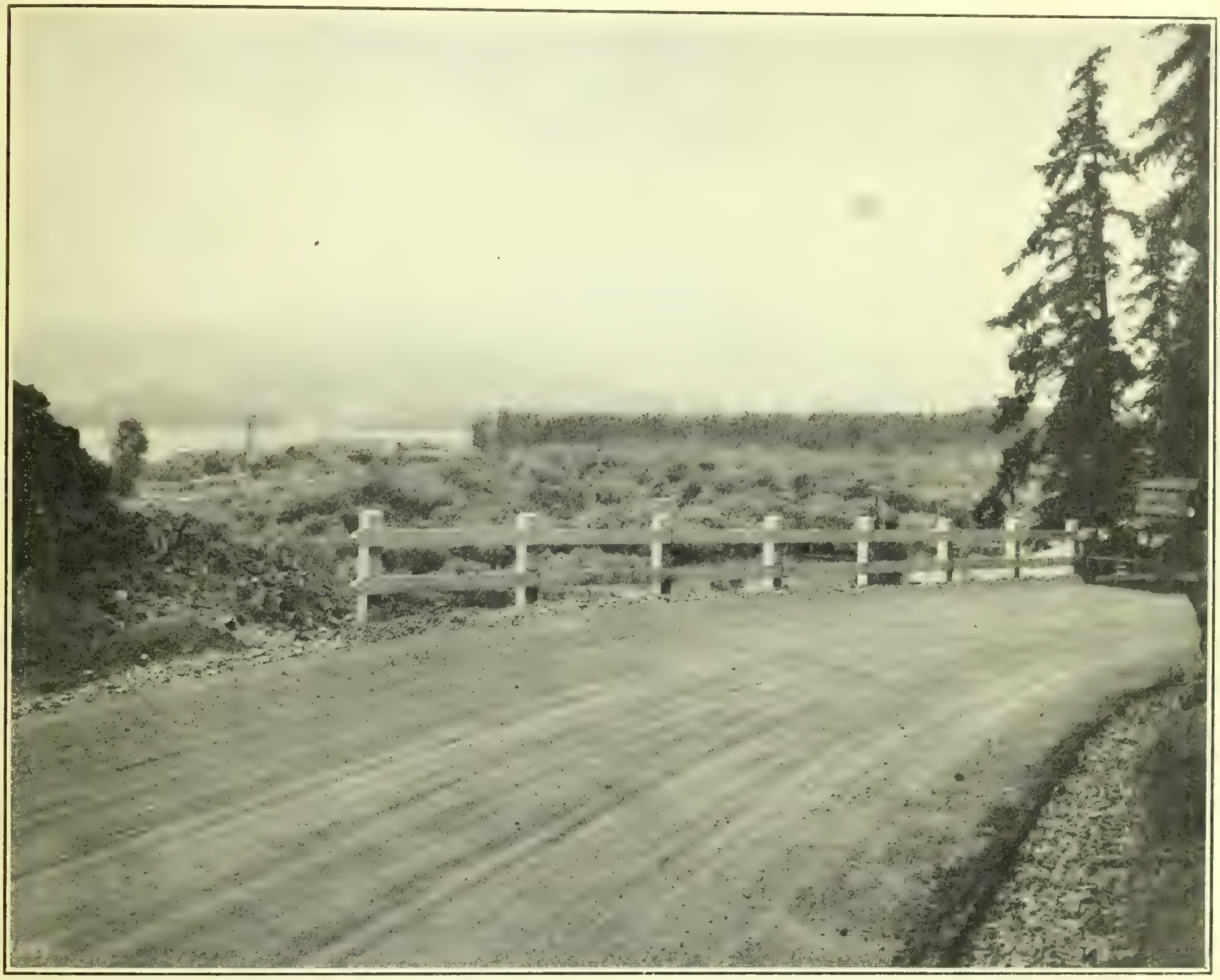
As a result of recent conferences between the State road commission of Utah and commissioners from almost all the counties of the State, the commissioners of Utah county have agreed to increase the amount of taxes to be raised in that county this year for roads from $179,013.35 to $278,342.35. Other counties have under advisement increases in the amounts originally provided. The road commission finds itself in an embarrassing position from the great increase of the cost of road construction, and it is seeking ways and means for securing funds with which to prosecute the program planned.

FOR OIL ROADS.

About 40 farmers attended a good roads meeting recently held at Adair, Ill. The oil question was discussed and plans matured for about 25 miles of oil roads in one township. The funds will be furnished by the commercial association and county and township treasuries.

Put your savings into war savings stamps and Treasury savings certificates—always worth more than you paid for them and not the kind of riches that take wings.

SUBSTANTIAL AND ATTRACTIVE GUARD RAIL ON OREGON ROAD



THE GUARD RAIL ERECTED WHERE NEEDED ALONG THE COLUMBIA RIVER HIGHWAY.

NO FEATURE of our modern roadways stands out more prominently in the eyes of the wayfarer than the guard rail erected at the roadside to protect him in the dangerous places. Weakness and poor design are in no other feature more quickly detected. Flimsiness spells the defeat of its primary purpose, but to achieve mere strength of construction, without artistry in line and proportion, is to lose an excellent opportunity for attractive roadside adornment.

Several types of guard rail have been developed by the State highway departments, which combine the attributes of solidity and grace, but none is more substantial or attractive than the type developed by Multnomah County, Oreg., and adopted by the Bureau of Public Roads for western Federal-aid roads.

This type was first used on the Columbia River Highway in places where a particularly substantial and artistic design was desired, and one that would be less expensive than the stone fence constructed along parts of the highway.

The posts, which are planted 8 feet from center to center, consist of 8-inch by 8-inch timbers, surfaced on four sides, and stand 4 feet 3 inches above the ground. Normally they are set 3 feet 9 inches into the ground, but are carried to greater depth as required by local conditions. To protect them from moisture they are painted with an approved bituminous paint for a length of 4½ feet from their lower ends.

The two rails, consisting of 3-inch by 8-inch timbers, also surfaced on four sides, are spiked or drift-bolted to the posts, and great care is observed, by drilling for bolts and even for spikes, if necessary, to prevent the splitting of the rails. They are cut to the length necessary to span two panels of the fence, and are squarely butt-jointed at the posts, the two rails breaking joints.

Before erection all contact surfaces and the tops of the posts are treated with one heavy coat of a white paint, consisting of white lead and zinc oxide in the proportions of 3 to 1 by weight, mixed with raw linseed oil and turpentine drier.

After erection the entire exposed surface of the fence is given three coats of the same white paint. As it has been found that the bituminous paint used as a preservative has a tendency to turn the white paint yellow, it has become customary to paint a black band around the posts for a distance of about 9 inches above the ground, or high enough to cover the part of the bitumen-treated section of the post which is above ground. As each post is thus painted to the same height above the ground, the contrasting color really adds to the appearance of the fence.

Bid prices for the construction of the fencing of this type on the Columbia River Highway projects ranged from 60 cents to $1 per lineal foot. The estimated cost per 8-foot panel is tabulated as follows:

75 feet b. m. lumber, at $40	$3.00
Setting and framing 1 post	1.00
Paint, 3 coats	.60
Bituminous preservative per post	.20
	4.80
Plus 20 per cent profit	.96
Estimated cost	5.76

REMAINS OF U. S. TROOPER EXCAVATED ON FEDERAL-AID ROAD

Resident Engineer J. J. McCreedy tells an interesting story in connection with the construction of Idaho Federal-aid project No. 6. This improvement consists of grading and draining a highway from the town of Whitebird, situated on the Salmon River, to the plateau 3,000 feet above, and thence to Grangeville. The country is extremely rugged. In the light of the morning sun the peaks of the hills, the folds and creases in the sides of the principal and subordinate valleys, have the appearance of a blanket thrown over the bed of the giant earth.

On September 9, 1919, workmen engaged in excavating the new roadway with a caterpillar steam shovel uncovered the remains of a United States trooper. He had died with his boots on. Nothing remained of the uniform, except the black visor of the military cap, brass buttons eroded beyond recognition, and black leather half-knee boots fairly well preserved. A brass spur fastened to the left boot recalled the rigid economy practiced by the Government during the life of the soldier. Silver-rimmed spectacles rested on the skull. The skeleton was well preserved and the teeth were in excellent condition.

In 1877 the Nez Perce Indians under Chief Joseph attempted the massacre of the settlers in Whitebird and the surrounding territory. Whitebird, situated in the Salmon River Canyon, was at that time a placer gold mining camp. A troop of United States cavalry, together with local Indian fighters, was dispatched by Gen. Howard from Fort Lapwai (12 miles east of Lewiston), under the direction of an Indian guide. This treacherous informer led the band into the canyon 2 miles north of Whitebird.

Relying on his word that no Indians were near, the entire party dismounted for a rest and loosed the saddle girths on the ponies. Immediately the Nez Perce tribesmen, ambushed in the surrounding hills, opened fire, while the members of the band made attempts, with variable success, to ride in the loose saddles on the backs of the terrified horses. In the running fight which ensued 1 lieutenant and 32 troopers were killed and the balance escaped to Grangeville in safety. The volunteer experienced Indian fighters protected the retreat and made possible the escape of the troopers, some of whom were unaccustomed to this type of warfare.

The killed were buried temporarily by their comrades, who returned a few days after the fight. Later the remains were dug up and placed in permanent graves. Some of those covered hurriedly in the shallow pits must have been overlooked in this last burial, which would account for the skeleton which was excavated 1 mile north of the point where the troop was first surprised by the Indians. The road construction force have selected a more secluded spot in which they have placed the remains.

A 20-MILE DIRT ROAD.

Houghton County, Mich., will this year build what is known as the Painesdale to Ontonagon County line road, which is 20 miles long and will give needed road facilities to the more populous parts of the county. Houghton County has taken over from the State the surveying of the road through Ontonagon County.

IDAHO'S 1920 FEDERAL AID.

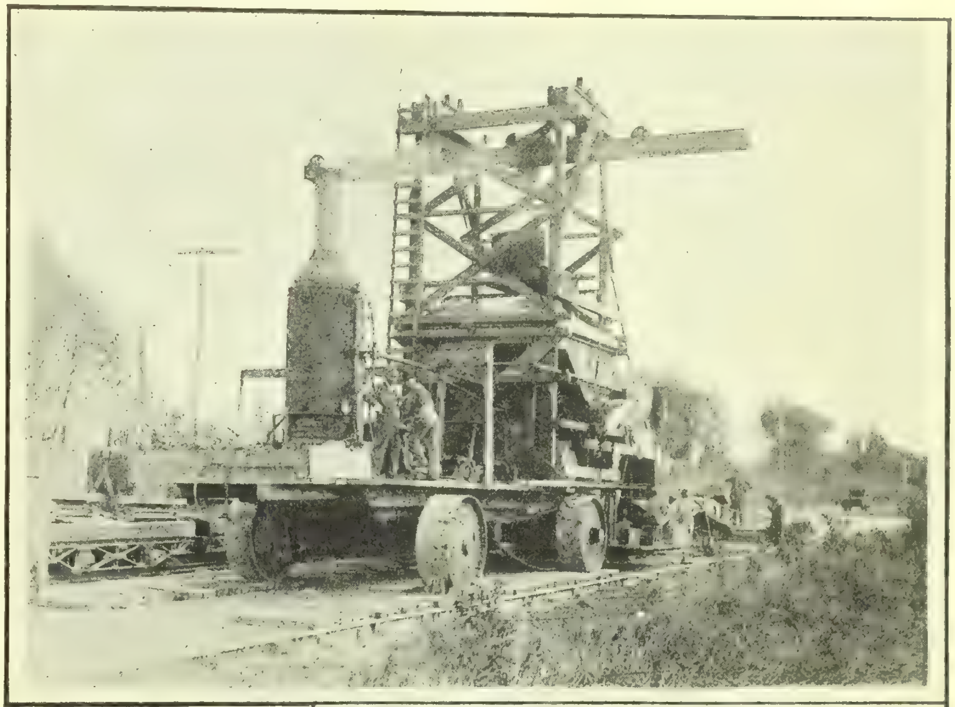
All of Idaho's share of the Federal-aid funds for 1920, $1,159,976, is already pledged to road projects in different parts of the State, according to the State commissioner of public works.

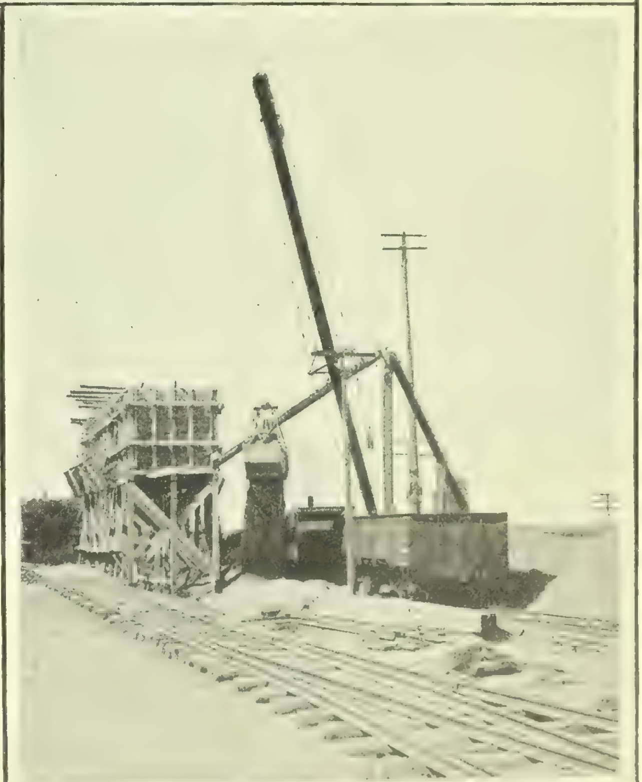
MACHINERY REPLACES HAND LABOR ON MINNESOTA PROJECT

By **GEO. C. SCALES**, Senior Highway Engineer, U. S. Bureau of Public Roads.

DURING the past three years there has been a very considerable increase in the cost of labor per unit of production. This increase is a reflection of the higher wages which are now paid for labor and of the decreased production per man which is the usual accompaniment of a surplus of work. The present is, therefore, a time when there is special advantage in reducing the requirements for labor by the substitution of machinery.

This high cost of labor per unit of work done prevails to-day in industry generally. However, it has, perhaps, been more noticeable in highway construction than in some other activities, for the reason that highway construction is not as well standardized as are most industrial activities and that, therefore, there is not the well-established standard of individual output which careful attention to detail has made possible in these other activities. Highway construction has generally been carried on by small organizations, and the nature of the work, as well as the fact that it is not a continuous industry in most communities, has prevented the development of any large body of men who are specially trained in many of the manipulations involved in ordinary highway construction. It follows that, to the general handicap caused by the fact that highway construction is not a well-organized or standardized industry, there is to be added the fact that the industry persists in a given locality only for a comparatively short time and that the rank and file of the laborers employed are, therefore, unaccustomed to the work. From this it follows that the laborers themselves have in their own experience no ready measure of a proper day's work. Hence, there has been a very marked tendency for all phases of highway construction which involve the use of common labor to increase in price out of all proportion to the increase in the actual wages paid for the work





MACHINERY ON MINNESOTA FEDERAL-AID PROJECT NO. 31. TOP—STEEL STONE AND SAND BOXES AT MIXING PLANT. SUBGRADE AND FORMS READY TO RECEIVE CONCRETE SURFACING. BOTTOM—SAND AND STONE STORAGE BINS, CRANE AND CLAM SHELL BUCKET AT RAILROAD SIDING.

performed. The increase in the cost of excavation is an excellent illustration of this fact. Five years ago ordinary excavation cost from 20 to 30 cents per cubic yard. The average cost was not far from 25 cents per cubic yard for ordinary light cuts and fills, which are a feature of highway construction and which involve a considerable amount of hand labor. For this work the wages of common labor were, at that time, approximately 20 cents an hour. To-day common labor can generally be secured for about 40 cents an hour, which is double the former rate: but it now is a very common thing to find bids for this same class of work running from 90 cents to well over $1 a cubic yard. The difference between the increese in the wages and the increase in the price paid for the work is the measure of the reduction in labor efficiency, due to the causes briefly outlined above.

In order to offset the falling off in labor efficiency, contractors for highway work are resorting to the extensive use of machinery. The proper performance of a machine is generally well known, and, therefore, its output is a measure of the efficiency of the operator. Thus, if a concrete mixer is designed to turn out 100 cubic yards of concrete in a given period, or if an engine is designed to haul a certain number of cars at a certain speed, or if a crane is designed to move certain loads, and if any of these machines fail to perform according to design the owner knows that, in all probability, the failure rests with the operation of the machine rather than with the machine itself, and promptly secures a new operator. In this way the performance per man can be held somewhere near to a standard schedule with more or less disregard for any general condition of labor efficiency such as exists at the present time. It is, therefore, particularly profitable at this time to use machines in the construction of highways, not only on account of the natural saving in labor, which well-designed machines make possible, but also because, during times like the present, well-operated machines tend to stimulate the productivity of labor.

MINNESOTA FEDERAL-AID PROJECT 31.

These general principles explain the extensive use of machinery by A. Guthrie & Co., of St. Paul, in the construction of Minnesota Federal-aid project No. 31. This project, involving the construction of 9 miles of concrete pavement, is divided into two sections; one extending 3 miles east from the city limits of Willmar, and the other 6 miles west from the town. The pavement is a standard one-course concrete pavement of 1:2:4 mix, and is laid 18 feet wide, 7½ inches thick at the center, and 6½ inches thick at the edges. The road was graded in 1918 so that the contract awarded to A. Guthrie & Co. involves subgrade work only to the extent of the shaping up of an existing subgrade and laying some drain tile. The main part of the contract involves the placing of 94,494 square yards of concrete pavement, for which the price bid was $2.44 per square yard.

The road is practically level, but there are occasional grades, the maximum being 2½ per cent. The Great Northern railway parallels the project for approximately a mile, and to facilitate the construction work a siding and unloading plant have been located about a mile from the east end of the project. Here the usual storage space has been provided and a construction camp established.

FEATURES OF UNLOADING PLANT.

The extensive utilization of machinery which has characterized the whole work began with the unloading plant. This consists of a stiff-leg derrick, which is provided with an exceptionally long boom. The derrick is so placed that the boom can readily drop the material taken from the cars over an extensive storage area or into a stone bin erected on the opposite side of the track. By the use of a derrick of this type it is possible to reduce the bin capacity so that the cost of loading bins is comparatively small.

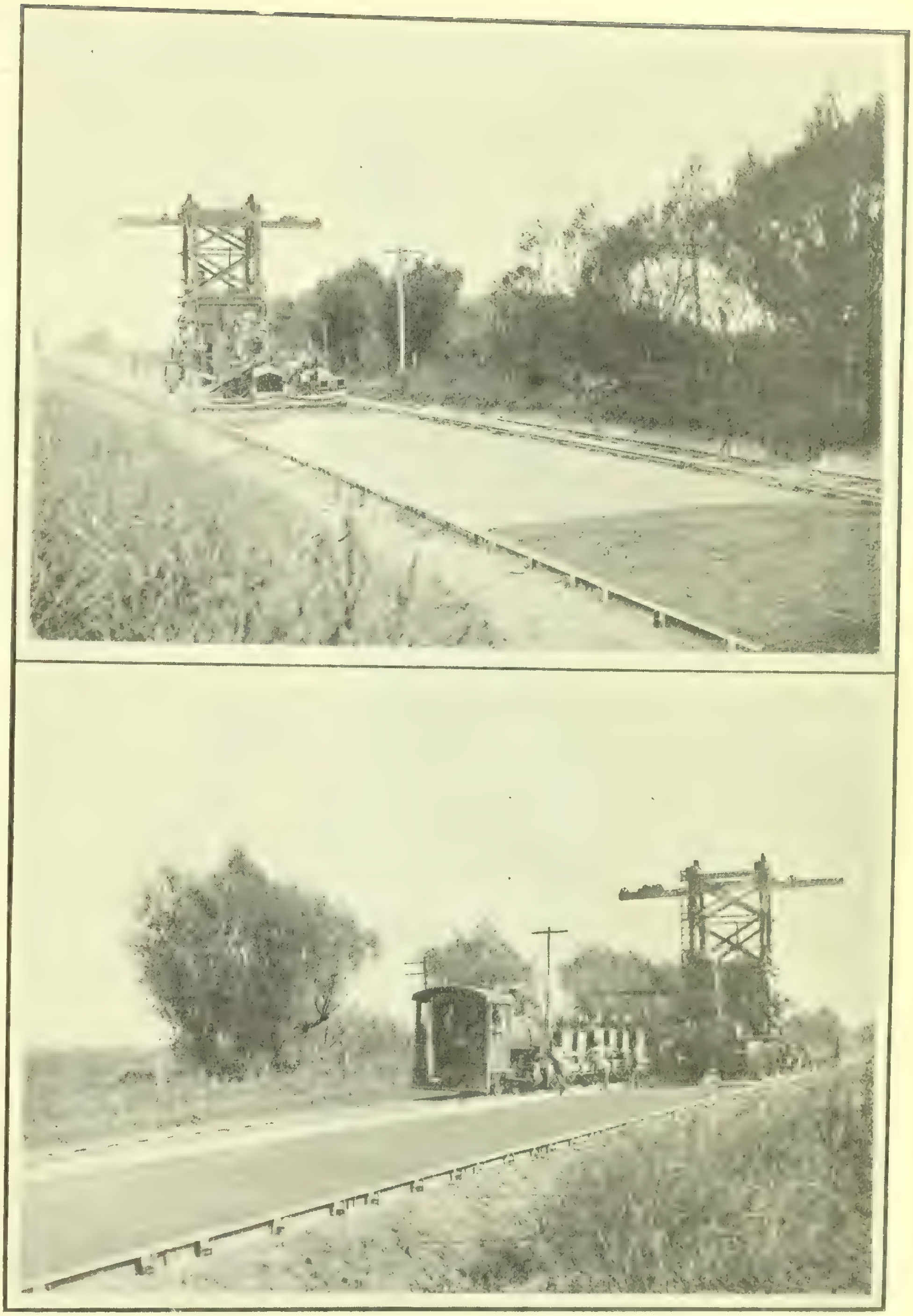
The bin is of standard construction, about 40 feet long, 8 feet wide, and 12 feet deep, and was elevated far enough above the ground to provide for gravity discharge. The length of the bin is so divided that one-third of the space is reserved for sand and two-thirds for gravel; six chutes are provided, so that as the industrial cars are spotted for loading six of the buckets which they carry can be loaded at one time. In these respects the bin, as erected, is normal.

The rest of the equipment at the unloading plant consists of the usual water tanks, pumps, boilers, etc. A one-half cubic yard clamshell bucket is used in unloading the cars and in moving material from the stock piles to the bins. A cement storage shed of 3,000-sack capacity is also provided. There are no unusual features in any of these items.

To operate this plant one derrick operator, a fireman, and two laborers are employed. It has been found in practice that from 15 to 20 cubic yards of aggregate can be handled per hour. The maximum performance with this crew has been 200 cubic yards in one 10-hour shift. After making full allowance for all costs, such as the erection of the plant, depreciation, and interest charges, the cost of unloading material from the cars in which it is received and placing it aboard the cars on which it is hauled to the mixing plants is about 50 cents per cubic yard. This cost may be subdivided as follows: Labor 27½ cents, coal, oil and waste 7½ cents, interest and depreciation 15 cents, total 50 cents.

THE INDUSTRIAL RAILROAD TRACK.

All materials are moved from the unloading plant to the mixing plant on a standard 36-inch industrial railroad track. The equipment used consists of



MINNESOTA FEDERAL-AID PROJECT NO. 31. TOP—CONCRETE MIXER AND STORAGE BINS, FINISHED PAVEMENT AND TAMPING MACHINE. BOTTOM—STORAGE BINS FOR SAND AND STONE AT MIXER, HOISTER DEVICE FOR UNLOADING CARS TO BINS.

three 16-ton engines and 24 flat cars and a full set of steel-bottom dump buckets of 35 cubic feet capacity. The rails used in the industrial track are standard 40-pound rails. They are laid on 4-inch by 6-inch by 5-foot hewed pine ties, 14 ties to each rail length. The laying of the track cost about $350 per mile and taking it up for relaying costs about $175 per mile. These comparatively low costs are, of course, made possible by the fact that the track is laid on the shoulder of the highway, which made it possible to place the track with almost no expense for preparing the subgrade. On the other hand, the liberal use of ties, though somewhat expensive, is fully justified by the fact that it facilitates track alignment and reduces the labor of maintenance. During the progress of the work no time has been lost on account of derailments or other difficulties chargeable to the condition of the track.

The standard train consists of seven cars, one of which may be loaded with cement, two with sand, and four with broken stone. This loading has not always been used, the cement having very generally been sent out a trainload at a time, a method of handling it which seems better suited to this particular job. The process of loading trains is standard for this class of equipment. The empty train is backed to the bins and so placed that six of the material buckets, of which each flat car carries two, are in position under the chutes. After these are loaded the train is shifted to a position which permits of the filling of the remaining buckets. The operation of loading a train takes about five minutes.

On this project it has been found that with two trains operating over a 6,000-foot haul and laying about 300 linear feet of pavement per shift, the trains are idle about 30 per cent of the time. No time has been lost on account of accidents. From this it is calculated that the material needed at the mixing plant can be supplied by two trains as long as the haul remains less than 2 miles, and that three trains will serve the mixing plant at a distance of 3 miles from the bins. On this particular project, as the grades are light, it is probable that three trains can serve the mixer at a considerably greater distance than 3 miles, for trains of the length here noted as standard can be operated on a 6 per cent grade, so of course, where the grades are as nearly level as they are on this project longer trains would be more feasible than additional trains.

OPERATING THE TRAINS.

Under the operating conditions prevailing on this project it has been found that a locomotive consumes about 1,000 pounds of coal per locomotive shift. The crew consists of one locomotive driver and one brakeman per train, and operated in this way, including the cost of laying, maintaining, and moving the track, as well as all depreciation and interest charges on the equipment used, the cost of handling aggregate is about $2 per cubic yard for a 3-mile haul. In the nature of the case the cost can not be reduced greatly for shorter hauls. It would be somewhat increased by longer hauls.

One of the most important features in the operation of equipment of this kind is the placing of the switches. On this project the switches are placed about a mile apart. It is doubtful, however, as to whether this practice will prove to have been as economical as the practice of adjusting the position of the switches to the time required in loading, unloading, and moving the trains. There is, of course, a distinct difference in the manner in which the trains must be operated on different projects, depending principally on the methods used in loading and unloading the number of cars on hand. If cars enough are available so that an empty train can be left for loading and a train of loaded cars taken out at once, the standing time of the engine at the loading bins is reduced and the proper position of the switches correspondingly modified. In any event, an arbitrary location of the switches is usually undesirable, as it tends to increase the standing time of the trains. A more advisable practice would seem to be to calculate the average time of loading, the average time of unloading, and the running time between loading and unloading points, and regulate the position of the switches accordingly.

TRAVELING STORAGE BIN.

The unusual feature of the equipment used on this project is the traveling storage bin designed to serve the mixer. This bin, or bins, for there are two compartments, are built on a large platform carried on four wide-tired wheels, the combined storage capacity of the two bins being 12 cubic yards.

Over the bins there is erected a traveling crane, consisting of a light hoist which runs on a heavy beam supported over the bins, and which is operated by means of an engine and drums carried by the platform. By means of this device the buckets delivered over the industrial railroad tracks are lifted off the cars, placed over the bins, and dumped, the coarse aggregate into one bin, the fine aggregate into the other. On the platform also are the propelling engine and an upright boiler which furnishes steam for the hoisting and propelling engines and for the mixer engine as well.

The bins discharge directly into the loading skip of the concrete mixer. This loading skip is divided into two compartments, one of 6 cubic feet capacity for sand and the other of 12 cubic feet capacity for stone. These compartments are filled by opening ordinary gates in the bins of the traveling platform. The process is therefore extremely simple and the accuracy of the measurement easily gauged. Cement is placed in the skip by hand from a flat car alongside the mixer.

The concrete plant and its operation are standard, and therefore require no comment. All finishing work is done by a mechanical tamper of standard make and design.

COMPARISON OF LABOR RESULTS POSSIBLE.

This plant is interesting not only in its design, but because the manner in which the materials are handled makes possible an exact comparison between the force employed and that which would have been required had old hand-labor methods been employed. Thus on this job the moving platform replaces wheelbarrow loading; transportation of materials by industrial railway is substituted for the more common transportation by team or truck; unloading materials with a crane replaces the older methods of hand labor; and the force at the mixer is directly comparable with the operating force ordinarily employed in handling materials, manipulating the mixed material, setting forms, etc. On this project the crew at the mixer consists of a hoisting engineer, a fireman, 1 mixer engineer, 1 man on the sand and stone chutes, 2 men handling cement, 2 men spreading concrete, 1 man operating the finishing machine, 4 men employed in removing forms, watering pavements, etc., and 2 men setting forms, making a total crew of 1 foreman and 15 men. This crew, as suggested above, is directly comparable with the standard crew employed where no loading devices are used, and the saving in labor offers a direct measure of the value of this method of handling materials.

The equipment has worked satisfactorily when the subgrade is dry, but in this particular case the heavy load concentrated on the four wheels of the traveling bins has been too heavy for easy manipulation after the subgrade has been saturated by a number of days of continuous rain. To avoid this difficulty, it is suggested that somewhat smaller hoppers might be more advisable, and that it would also be advisable to distribute the load on a larger number of wheels, thus reducing the unit load so that the subgrade would not be rutted as the hoppers are moved forward.

The advantages of this method of operation, aside from the general advantages which have been noted, are that it eliminates storage of materials on the subgrade and thus preserves the materials in better condition for use, and that it prevents, to a degree, the rutting of the subgrade, which is an inevitable concomitant of delivery of materials by team or motor truck. As tending to offset these advantages there is, of course, the cost of constructing the traveling platform and of moving it over the highway, which will, it is suggested, be largely, if not entirely eliminated wherever the grades are steep. It would therefore seem that this method, though interesting, and on this project successful, should be adopted only after a careful consideration of the conditions which will be met on other projects, and that it will be found to be inapplicable wherever adverse grades of more than 2 or 3 per cent are to be encountered.

The project, as noted above, is being constructed by A. Guthrie & Co., of St. Paul, with A. Lizee, superintendent in actual charge of the work. H. L. Wardell is the engineer in charge of the work for Kandiyohi County.

CONCRETE PRESSURE AGAINST FORMS

By Earl B. SMITH, Senior Assistant Testing Engineer, U. S. Bureau of Public Roads.

THE cost of forms for concrete work constitutes in many cases a large percentage of the total cost of the finished structure, and this cost can only be kept within reasonable limits by rationally studied design methods. In so many cases the form is not designed, but is merely laid out by guess and constructed by the carpenter, with the result that an unwarranted amount of lumber has been used to prevent failure or spreading. The dimensions and the spacing of the supports and braces should receive careful attention to secure sufficient stiffness and ample strength. The sheathing and bracing should be so proportioned as to secure ample stiffness against springing and misalignment. Mere strength without ample stiffness and rigidity is not sufficient for good work.

The proper design of forms can not be effected without knowing the lateral and vertical pressures of plastic concrete against the forms. To secure this information the United States Bureau of Public Roads has made a few tests which seem to accord in general with the results obtained by others,[1] but which go further in indicating the values of some of the factors influencing the results. At the present time sufficient data have been obtained to make any final statement as to the law of pressure of concrete and the effect of each factor, but rather than hold this data longer with the expectation of making it more complete at some future date, it is now offered with the hope that it may serve to make a little more definite the usual practice in the design of concrete forms; also that it may suggest a needed field of investigation for other experimenters.

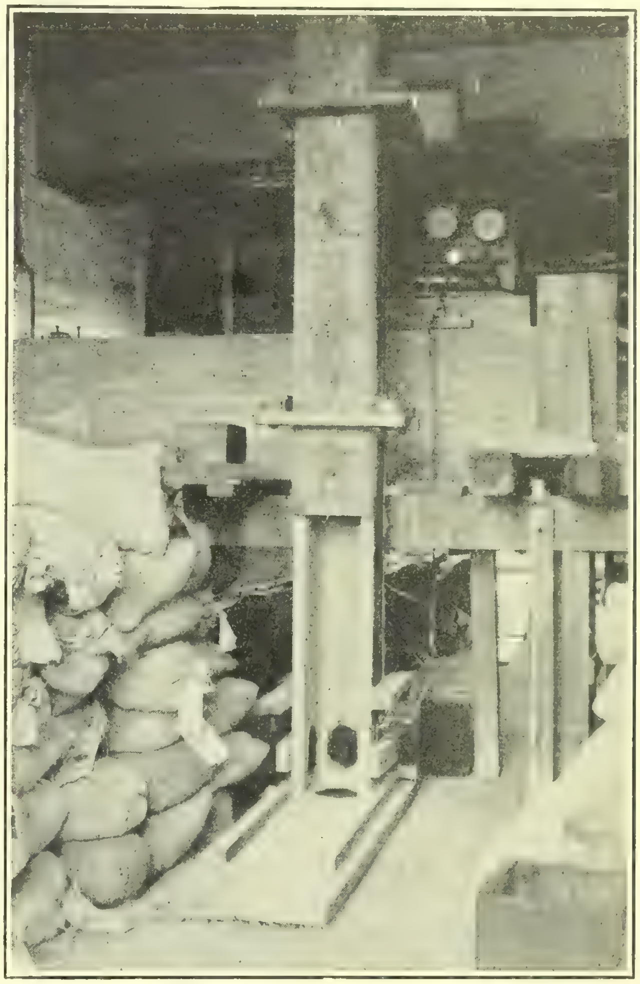


FIG. 2.—SHOWING FORM AND LOCATION OF PRESSURE CELLS.

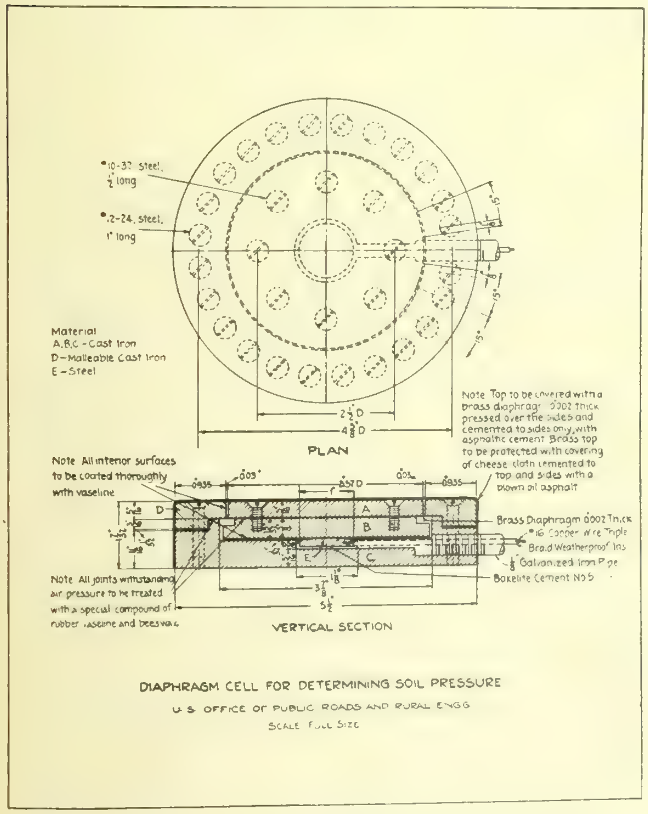

•10-32 Steel, ½" long
•12-24, Steel, 1" long
15°
15°
15°
Material
A, B, C – Cast Iron
D – Malleable Cast Iron
E – Steel
2½" D
4⅝" D
PLAN
Note Top to be covered with a brass diaphragm .0002 thick pressed over the sides and cemented to sides only, with asphaltic cement Brass top to be protected with covering of cheese cloth cemented to top and sides with a blown oil asphalt
Note All interior surfaces to be coated thoroughly with vaseline
.0935
.003"
.357 D
.003
.0935
r
A
B
C
D
E
Brass Diaphragm .0002 Thick
#16 Copper Wire Triple Braid Weatherproof Ins
⅛" Galvanized Iron Pipe
Bakelite Cement No 5
1⅛"
3⅞"
5½"
Note All joints withstanding air pressure to be treated with a special compound of rubber vaseline and beeswax
VERTICAL SECTION
DIAPHRAGM CELL FOR DETERMINING SOIL PRESSURE
U. S. OFFICE OF PUBLIC ROADS AND RURAL ENGG
SCALE FULL SIZE

FIG. 1.—DIAGRAM CELL FOR DETERMINING SOIL PRESS.

TESTS TO DETERMINE PRESSURE.

The series of tests presented in this paper was carried out by Mr. W. E. Rosengarten in the laboratory of the research section of the Bureau of Public Roads located at the Arlington Experimental Farm, near Washington. The field tests were made during the construction of the walls and columns of a reinforced concrete building.

The apparatus used to measure the concrete pressures were cells and gauges similar to those described in the Proceedings of the American Society for Testing Materials, 1917, page 641, and used for the past few years by this laboratory in measuring earth pressures behind retaining walls and under fills. Details of the instrument are shown in the accompanying figure 1. It consists essentially of an air-tight metal cell having a circular weighing face 10 square inches in area. The concrete pressures against the face of the cell are balanced by admitting compressed air to the inside of the cell. When the pressures are balanced an electrical contact is broken which extinguishes a light and indicates that the pressures shown on the gauge connected with the air pipes is equal to the pressure of the concrete. Tests on these cells show them to be accurate considerably beyond that necessary for these tests, and that the movement of the face is less than one ten-thousandth of an inch to break contact, thus making the cell admirably suited for tests of pressures exerted by granular materials, such as soils, mud, and concrete.

---

[1] Design of Concrete Forms, R. A. Sherwin, Eng. Record, Feb. 26, 1916, p. 278; Pressure of Concrete on Forms, F. R. Shunk, Eng. News, Sept. 9, 1909, p. 288; Pressure of Wet Concrete on the Sides of Column Forms, A. B. McDaniel and N. B. Grover, Eng. News, May 18, 1916, p. 933.

SUITABLE APPARATUS IMPORTANT.

Several other experimenters have attempted to obtain such data, but some have been greatly handicapped by not having a suitable apparatus for determining the concrete pressures. Any scheme for determining the pressure values that depends upon a movement of the concrete at the time of making the readings is evidently not reliable. The values desired are the static pressures of concrete against an immovable surface, and not the pressures necessary to stop a moving mass of concrete, nor to start a movement of the mass. And any scheme requiring first the disturbance or movement of the mass before making the pressure readings is also undesirable.

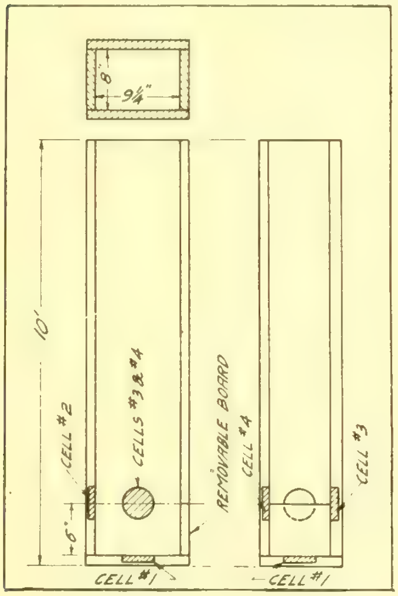
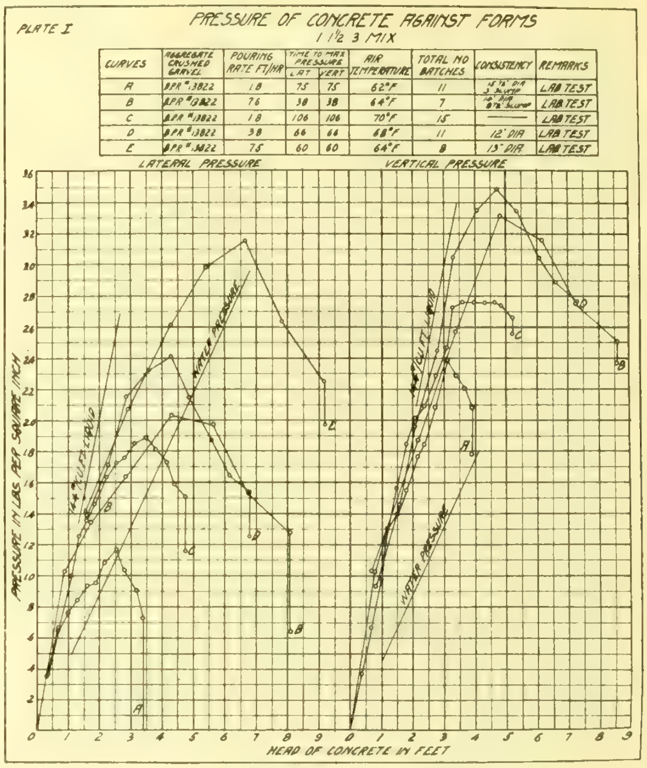


FIG. 3.—SKETCH OF FORM USED FOR MEASURING PRESSURE OF CONCRETE.

The arrangement of the pressure cells and the concrete form used during the laboratory tests is shown in the accompanying figures 2 and 3. The form was built of 2-inch planks giving an inside horizontal cross section of 7.8 inches by 9.4 inches, and a height of 10 feet. Four cells were placed in the form, with the weighing face flush with the inside of the forms. Cell No. 1 was placed in the center of the base and indicated the vertical pressure. Cell No. 2 was set in the center of the rear wall of the form. Cells Nos. 3 and 4 were placed in the center of the right and left side walls of the forms, respectively. The centers of these cells for obtaining the lateral pressure were all 6 inches above the base. Air-control pipes leading from all cells were arranged in order, with connections and nipples conveniently located for taking the readings on the four cells very quickly.



CURVES	AGGREGATE CRUSHED GRAVEL	POURING RATE FT/HR	TIME TO MAX PRESSURE		AIR TEMPERATURE	TOTAL NO BATCHES	CONSISTENCY	REMARKS
			LAT	VERT				
A	APR #13822	1.8	75	75	62°F	11	15 ½" DIA 3" SLUMP	LAB TEST
B	APR #13822	7.6	38	38	64°F	7	10" DIA 8½" SLUMP	LAB TEST
C	APR #13822	1.8	106	106	70°F	15	——	LAB TEST
D	APR #13822	3.8	66	66	68°F	11	12" DIA	LAB TEST
E	APR #13822	7.5	60	60	64°F	8	13" DIA	LAB TEST

FIG. 4.—LABORATORY TESTS.

MAKING THE TESTS.

The materials for the concrete used in the tests were carefully weighed and mixed by hand. Immediately upon completing the mixing the concrete was shoveled into buckets and dumped into the top of the forms. The mixing floor and the wood forms were well wetted before the test was begun. The concrete was tamped on top by the use of a long stick having a 2-inch by 6-inch foot on the lower end. The forms were also vibrated by striking the outside with a heavy hammer. The height to which the concrete stood in the column form was then measured, and the pressures on the bottom and three side cells were immediately read and recorded. The batches were varied in size so that when a new batch was added each 10 minutes the head of concrete in the form would increase at the rate desired. Readings were taken on the pressure cells immediately after placing the concrete and again about five minutes later, or shortly before placing the next batch of concrete.

The air and the mixing water temperatures were recorded each day tests were run. Slump tests of the concrete were made to determine the consistency used in each test; and are recorded as inches slump, or where very wet as inches diameter of the mass. Fresh batches of concrete were added every 10 minutes until after the pressures on the cells had passed a maximum and indicated a decided decrease in pressure. The tabulated data and results of these laboratory tests are shown in Table I, and also, in graphical form, in figures 4 to 7, inclusive.

Several field tests were run, in addition to the laboratory tests described above, during the construction of a reinforced concrete building at the

Arlington Farm. The pressure cells were inserted in the wall and column forms as shown in the accompanying figures 8, 9, and 10, and pressure readings taken at the time the concrete was being poured. The concrete was machine mixed, raised in an elevator, and directed into the forms through a system of chutes. It was then spaded or tamped with a stick with a small blade on the end. The concrete was a 1 : 2 : 4 mix, river gravel being used for the coarse aggregate, and the consistency rather sloppy, flowing readily around the steel reinforcing. The results from these field tests conform favorably with those obtained from the laboratory and are shown in Table II, and figure 11.

TABLE I.—*Tests of pressures of concrete against forms.*

Test No. data.	Mix.	Aggregate.	Consistency.	Temperature.		Rate of pouring per hour.	Maximum pressure.		Head at maximum pressure.		Time at maximum pressure.	
				Air.	Water.		Vertical.	Lateral.	Vertical.	Lateral.	Vertical.	Lateral.
1918.				°C.	°C.	Feet.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
June 17	1:2¼:3¾			23		1.50	1.15	0.68	2.50	2.00	90	90
June 18	do			26		2.70	1.45	.90	3.70	2.50	78	61
June 19	do					3.30	1.65	.73	3.30	2.50	49	44
Nov. 23	1:3:6	Cement, 13820	Quaky	19	21	1.63	13.50	.52	2.77	1.70	79	61
Nov. 26	do		Quaky (forms)	15	18	3.32	1.05	.43	4.15	2.53	70	50
Nov. 30	do		Quaky (dry)	19	20	6.72	1.07	.21	6.59	3.80	57	37
Dec. 4	do		Quaky	17	19	14.26	1.33	.41	10.00	5.12	48	29
Dec. 9	do		do	17	21	[1] 9.00	.86	.35	9.28	8.78	10	10
Jan. 17	do	Gravel, 13822	do	21	19	1.73	.98	.90	1.71	2.08	36	66
Jan. 13	do	New lot cement	Quaky (first test, forms wet)	18	20	3.46	2.02	.85	3.72	3.22	57	57
Jan. 14	do	do	Quaky	16	19	7.08	2.53	1.40	5.50	5.00	49	49
Jan. 31	1:2:4	Gravel, 13822	Quaky (14-inch diameter)	19	18	1.75	2.27	1.50	3.16	2.68	96	86
Mar. 1	do	New cells	Quaky (13-inch diameter)	24	18	3.60	2.35	1.46	4.50	3.40	66	56
Mar. 3	do	do	do	23	23	7.32	1.73	1.21	4.55	4.05	37	37
Jan. 18	1:1½:3	Gravel, 13822	Quaky	21	24	1.86	2.75	1.89	3.99	3.49	106	106
Jan. 20	do	do	Quaky (12-inch diameter)	20	17	3.84	3.49	2.40	4.79	4.29	66	66
Jan. 21	do	do	Quaky (13-inch diameter)	17	17	7.50	4.60	3.16	7.10	6.60	60	60
June 2	1:2:4	Fine gravel, No. 14192	Quaky (10½-inch diameter)	25	18	1.78	1.75	.98	2.09	1.87	16	56
June 3	do	do	Dry (6½-inch slump; 11½-inch diameter, 6½-inch slump).	27	18	7.35	2.41	1.93	3.33	2.83	28	28
Apr. 10	1:1½:3	Gravel, 13822	Sloppy (12½-inch diameter, 3-inch slump).	16	15	1.84	2.37	1.17	3.05	2.55	75	75
Apr. 12	do	This test and all previous crushed gravel, 13822.	Sloppy (14-inch diameter, 8½-inch slump).	17	15	7.66	3.31	2.05	4.80	4.30	38	38
Apr. 18	1:2:4	First test, fine gravel, 14192	Sloppy (17-inch diameter, 9½-inch slump).	18	17	1.86	2.75	1.63	3.38	2.88	85	85
May 9	do	do	Sloppy (16-inch diameter, 9½-inch slump).	19	17	7.44	1.97	1.19	3.33	2.83	27	27

[1] In one batch.

TABLE II.—*Field test of pressure of concrete against forms.*

Test No. data.	Mix.	Consistency.	Temperature.		Rate of pouring per hour.	Distance cell to opposite side of form.	Maximum pressure, lateral.	Head at maximum pressure, lateral.	Time at maximum pressure.
			Air.	Water.					
			°C.	°C.	Feet.		Lbs.	Feet.	Minutes.
Apr. 15	1:2:4	Sloppy	14	13	12.0	8 inches	1.95	3.25	17
					12.0	do	2.45	3.25	17
Apr. 17	do	do	14	15	20.0	3 inches to reinforcement	[1] 2.45	4.62	23
					20.0	18 inches	[2] 3.90	4.62	23
May 26	do	do	23	23	9.0	18 x 28 inch hole	2.20	3.00	20
May 26	do	do	23	23	12.5	9½ inches	1.85	2.30	11
May 26	do	do	23	23	10.6	do	1.45	2.30	13

[1] Stopped.

[2] Pour.

CONCRETE MATERIAL USED.

As a matter of record, the following information as to the concrete material is given:

Cement, Tidewater brand, passing standard specifications for cement.

The sand (Laboratory No. 13821) was obtained locally and consisted of angular quartz particles with some ferruginous clay and a little mica and magnetite. It showed a loss by washing of 6.6 per cent, with grading as follows:

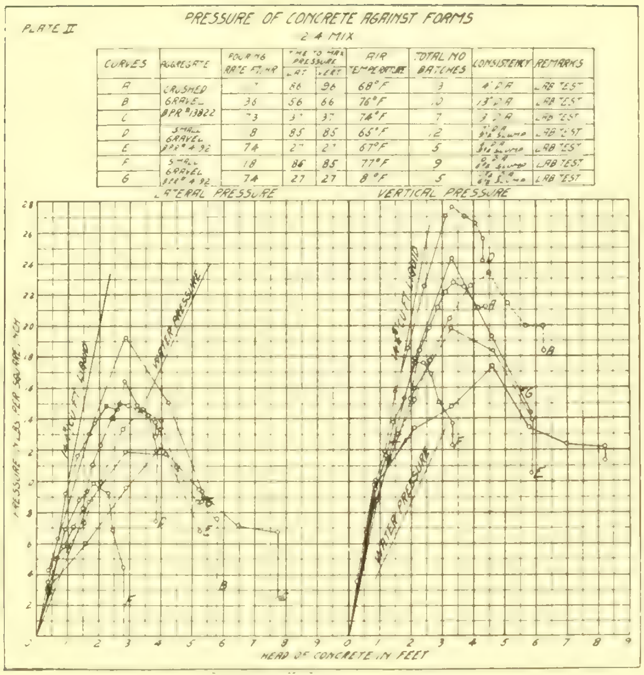
	Per cent.
All passing ¼-inch, retained on 10-mesh sieve	12.0
Passing 10-mesh, retained on 20-mesh sieve	15.2
Passing 20-mesh, retained on 30-mesh sieve	17.6
Passing 30-mesh, retained on 40-mesh sieve	14.6
Passing 40-mesh, retained on 50-mesh sieve	8.4
Passing 50-mesh, retained on 80-mesh sieve	15.0
Passing 80-mesh, retained on 100-mesh sieve	3.0
Passing 100-mesh, retained on 200-mesh sieve	6.4
Passing 200-mesh	7.8

The fine gravel (Laboratory No. 14192) consisted of subangular fragments of quartz with some chert and sandstone. The grading of this gravel is as follows:

	Per cent.
Passing 1½-inch, retained on 1-inch screen	2.8
Passing 1-inch, retained on ¾-inch screen	6.6
Passing ¾-inch, retained on ½-inch screen	29.2
Passing ½-inch, retained on ¼-inch screen	47.9
Passing ¼-inch, retained on 10-mesh sieve	11.9
Passing 10-mesh, retained on 20-mesh sieve	.2
Passing 20-mesh, retained on 30-mesh sieve	.1
Passing 30-mesh, retained on 40-mesh sieve	.1
Passing 40-mesh, retained on 50-mesh sieve	....
Passing 50-mesh, retained on 80-mesh sieve	.2
Passing 80-mesh, retained on 100-mesh sieve	.1
Passing 100-mesh, retained on 200-mesh sieve	.1
Passing 200-mesh	.8

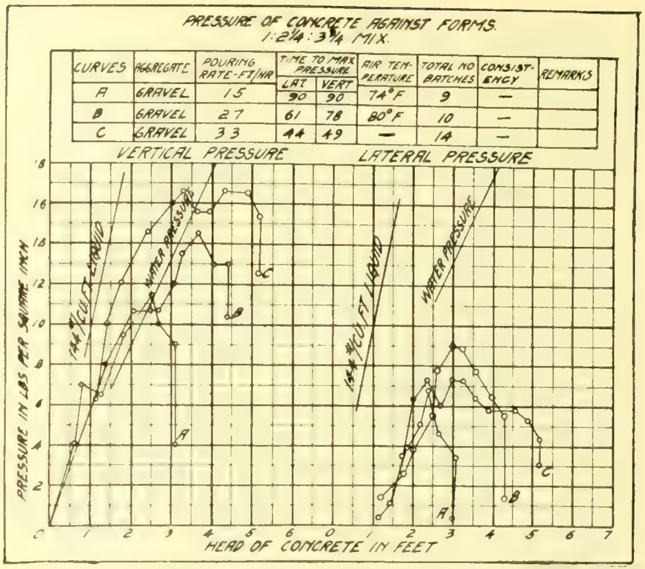
Crushed gravel aggregate. (Laboratory No. 13822.) This consisted of large, angular fragments of sandstone with a few rounded quartz pebbles with grading as follows:

	Per cent.
Passing 1½-inch, retained on 1-inch screen	30.3
Passing 1-inch, retained on ¾-inch screen	32.8
Passing ¾-inch, retained on ½-inch screen	18.1
Passing ½-inch, retained on ¼-inch screen	13.8
Passing ¼-inch screen	5.0



CURVES	AGGREGATE	POURING RATE FT/HR	TIME TO MAX PRESSURE		AIR TEMPERATURE	TOTAL NO BATCHES	CONSISTENCY	REMARKS
			LAT	VERT				
A	CRUSHED GRAVEL BPR #13822	[illegible]	86	96	68°F	3	4" DIA	LAB TEST
B		36	56	66	76°F	10	13" DIA	LAB TEST
C		[illegible]3	37	37	74°F	7	3" DIA	LAB TEST
D	SMALL GRAVEL BPR # 4 92	8	85	85	65°F	12	[illegible] DIA 9½ SLUMP	LAB TEST
E		74	27	27	67°F	5	[illegible] DIA [illegible] SLUMP	LAB TEST
F	SMALL GRAVEL BPR # 4 92	18	86	85	77°F	9	[illegible] DIA [illegible] SLUMP	LAB TEST
G		74	27	27	8 °F	5	[illegible] DIA [illegible] SLUMP	LAB TEST

FIG. 5.—LABORATORY TESTS.



CURVES	AGGREGATE	POURING RATE-FT/HR	TIME TO MAX PRESSURE		AIR TEMPERATURE	TOTAL NO BATCHES	CONSISTENCY	REMARKS
			LAT	VERT				
A	GRAVEL	15	90	90	74°F	9	—	
B	GRAVEL	27	61	78	80°F	10	—	
C	GRAVEL	33	44	49	—	14	—	

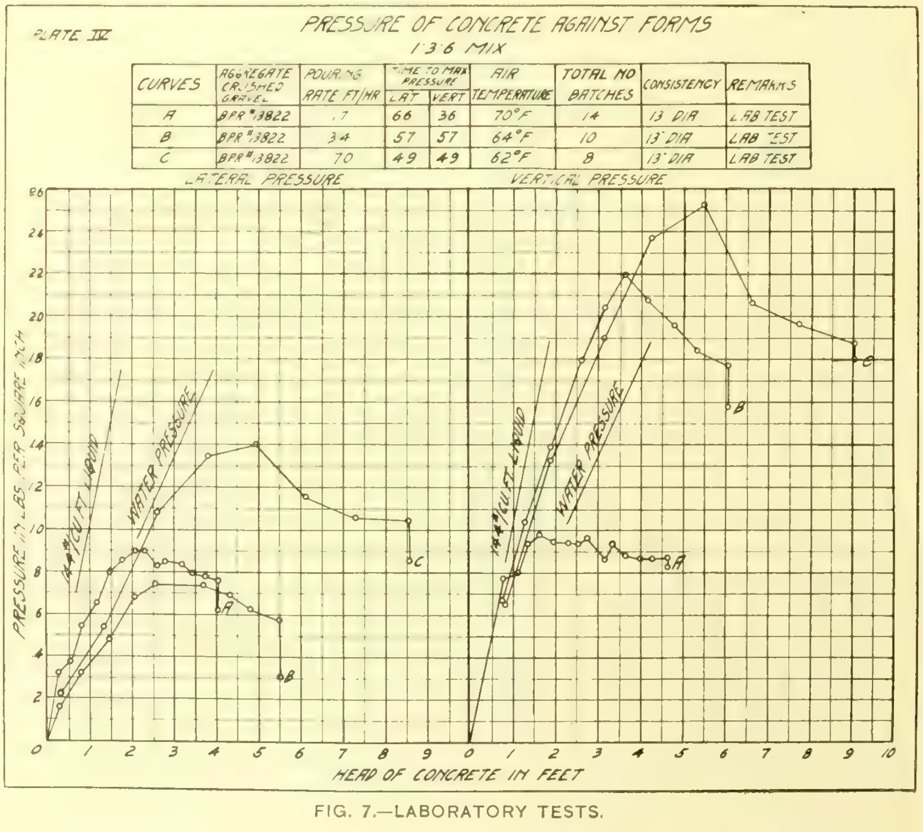
FIG. 6.—LABORATORY TESTS.

FACTORS INFLUENCING PRESSURE.

The results shown by these experiments indicate that the fundamental pressure of concrete against the form is about 1 pound per square inch for the first 1 foot of head. However, this is by no means all that should be said. A study of the results reported by others, and those obtained from this series of tests, shows that the following factors have an influence upon the pressure, namely, (1) rate of filling the forms, (2) cross-sectional area of the forms, (3) consistency of the concrete, (4) amount of cement in the concrete, (5) temperature of the concrete and the time of set and of the cement, and (6) character of the fine and the coarse aggregate.

Sufficient information is not yet available to make final statements as to the law by which each of these factors influences the pressure of the concrete against the form. The results do show that the initial pressure under small heads is equal to the hydrostatic pressure of a liquid having the approximate density or weight of the concrete; that is, approximately 1 pound per square inch, or 144 pounds per square foot, for the first foot head. As pouring is continued this pressure, however, soon falls below the straight line hydrostatic pressure, and the amount of this deviation depends upon one or more of the factors mentioned above.

It is important to notice that the results prove that if filling is continued indefinitely the lateral pressures near the base of the form finally reach a maximum value and then decrease gradually to zero, regardless of the fact that fresh concrete is continually added above. The vertical pressures are in all cases greater than the lateral pressures—they decrease in value after a maximum has been attained, but not to zero. The total weight of the concrete mass in ordinary construction is not supported entirely upon the bottom of the form, but because of the roughness and friction against the sides the planking takes part of the weight or vertical pressure. Of course, for wide and shallow masses of concrete such as floor slabs the vertical pressure is equal to the weight of the concrete.



CURVES	AGGREGATE CRUSHED GRAVEL	POURING RATE FT/HR	TIME TO MAX PRESSURE		AIR TEMPERATURE	TOTAL NO BATCHES	CONSISTENCY	REMARKS
			LAT	VERT				
A	BPR #13822	17	66	36	70°F	14	13 DIA	LAB TEST
B	BPR #13822	34	57	57	64°F	10	13" DIA	LAB TEST
C	BPR #13822	70	49	49	62°F	8	13" DIA	LAB TEST

FIG. 7.—LABORATORY TESTS.

EFFECT OF INFLUENCING FACTORS.

A summary of the data at hand seems to lead to the following conclusions regarding the effect of the various influencing factors:

(1) The maximum pressure exerted upon the forms increases as the rate of filling increases. At a slow rate of about 1 foot per hour the pressure is approximately 1 pound per square inch, but as the rate increases beyond this value the pressure increases approximately as the 0.3 power of the rate.

(2) Field tests, which were made in places where the distance between the form walls differed, indicate that the maximum pressures obtained increase slightly with the mass of the concrete when the consistency is wet and sloppy. This conclusion probably does not hold in the case of dry mixes. Reinforcing just inside the form tends to slightly decrease the pressures, but probably this effect should be neglected in determining the final pressures for use in design.

(3) The results show in general that the maximum pressure was increased as the consistency of the concrete was made drier within the limit of workability. This, probably, differs from what might be expected, but the tests show it to be the case. It is probably due to the fact that under the usual conditions of placing dry concrete it requires more tamping, which, because of its dryness, seem to develop a permanent wedging action between the particles. In the case of wet or sloppy concrete this wedging action does not exist, as we have approximately a static fluid pressure. For low heads the dry concrete (when tamped as usual) will give the greater lateral pressure, but for heads of 4 feet or more and within the time when initial set becomes an influencing factor the sloppy mixtures give the greater pressure. The average increase of pressure due to the effect of dry mixtures seems to be 0.3 pounds per square inch for each inch decrease in the standard slump test less than a 5-inch slump.

(4) The richness of the mix also affects the maximum pressures obtained. The richer the mix the greater the maximum pressure. The average increase being 0.12 pound per square inch for each per cent increase in the ratio of the cement to the aggregate beyond 12 per cent.

(5) A decrease in the temperature of the concrete retards the set of the cement, and it is natural to suppose that this is the limiting factor in the maximum pressure obtained, since the pressure increases with the head until the cement takes a sufficient set to begin to support the overlying concrete. Therefore, as the temperature is reduced and the time of setting is increased the height of fill may be increased and thus produce or make possible a higher total pressure. Since the cement begins to set and stiffen in about 30 minutes, the maximum pressure is attained under whatever head of concrete may exist at this time. The value for H, the head of concrete, to be used in the formula given below should not be greater than one-half the rate of fill, except where agitation is vigorous and continuous in a sloppy mix; then this ratio may be taken up to three-fourths.

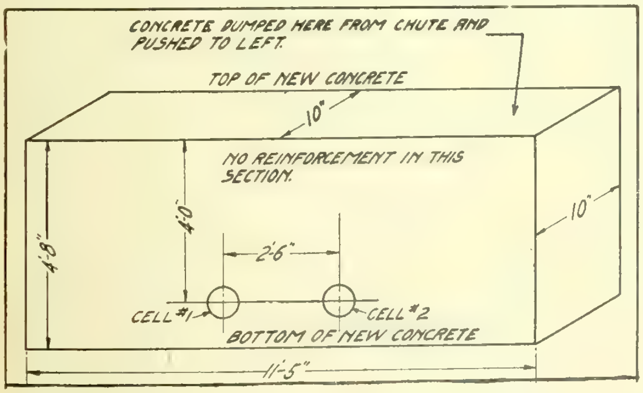

CONCRETE DUMPED HERE FROM CHUTE AND PUSHED TO LEFT.
TOP OF NEW CONCRETE
10"
NO REINFORCEMENT IN THIS SECTION.
4'-0"
4'-8"
10"
2'-6"
CELL #1
CELL #2
BOTTOM OF NEW CONCRETE
11'-5"

FIG. 8.—SHOWING LOCATION OF PRESSURE CELLS NOS. 1 AND 2, FIELD TESTS, DURING CONSTRUCTION OF REINFORCED CONCRETE BUILDING.

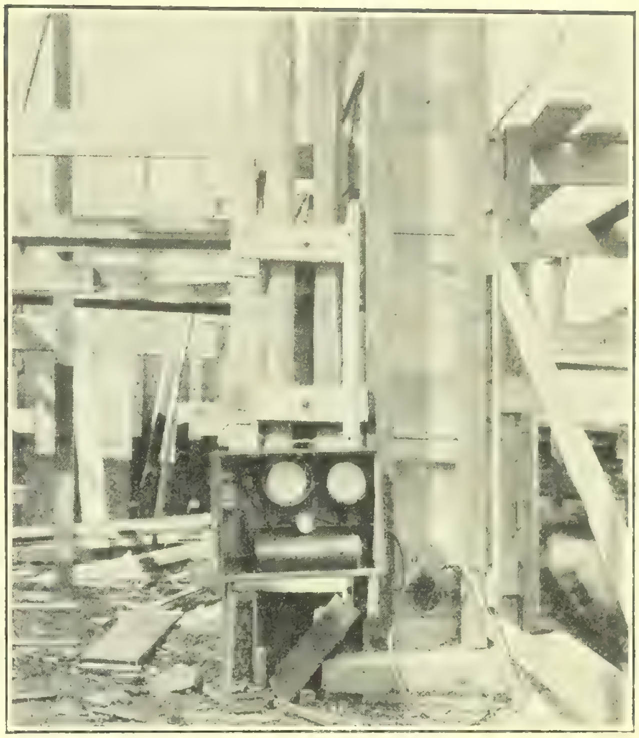


FIGURE 9.—SHOWING POURING OF COLUMN, FIELD TEST.

FORMULAS GIVING PRESSURES.

An empirical formula giving the lateral pressures required for use in the design or the investigation of the strength of concrete forms, and taking into account the above numerical factors, is

$$P = H^{0.2}R^{0.3} + 0.12C - 0.3S,$$

P being the resultant lateral pressure in pounds per square inch; R, the rate of fill in feet per hour; H, the head of concrete fill; C, the per cent by volume of cement to the combined fine and coarse aggregate; and S, the consistency in inches of slump.

The vertical pressure is obtained by adding $0.25H$ to the value of P as found above, except when the inside distance between the vertical sides of the form is greater than one-half the depth of fill; then the value should be taken as equal to the weight of the concrete.

In the practical application of this formula, as with all formulas, there is abundant opportunity for the exercise of common sense and good judgment. The formula may give pressures somewhat higher than exact values. It shows the effect of continuous and vigorous agitation of the concrete mass only as this is introduced through good judgment in selecting the value for the head of concrete, H. For usual conditions H may be taken as not greater than one-half of R. For ordinary cement in cold weather, or when continuously and well agitated, H may be three-fourths of R, when the filling is continuous beyond 1 hour. A second pouring on top of concrete that has been in place for 45 minutes or more does not add to the pressures already existing at the bottom of the fill.

The values for C may be taken as the next higher whole number in the per cent of cement by volume, as the required accuracy does not justify fractional per cents. Values for S may also be taken only as whole numbers, since the slump test is not accurate closer than 1 inch.

The value of P obtained by the formula is the lateral pressure against the form at the lowest point of the fill. Since the pressures are not uniform from top to bottom, but vary approximately as the ordinates of a parabola, the center of pressure or point of resultant pressure may be taken at 0.6 of the height of fill, H, from the top.

USE OF THE FORMULA.

The following examples may serve to show the use of the above formula:

Example I.—For reinforced mass concrete. Mix to be 1:3:5; consistency, rather sloppy, or 9-inch slump; the rate of fill, R, to be 8 feet per hour. The total height of concrete filled within 1 hour, 7 feet. Since this concrete is placed by means of a chute in a large form, and men are continually walking around in it, the value to be chosen for H is 6, or three-fourths of R. Then, substituting in the formula—

$P = 6^{0.2}8^{0.3} + (0.12 \times 13) - (0.3 \times 9)$.
$P = 1.53$ pounds per square inch.
The vertical pressure = 7 pounds per square inch.

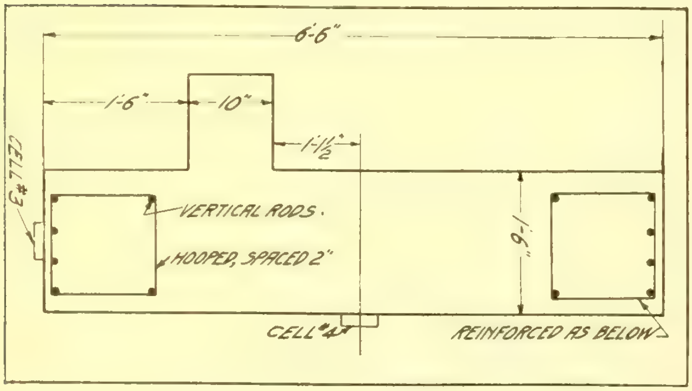
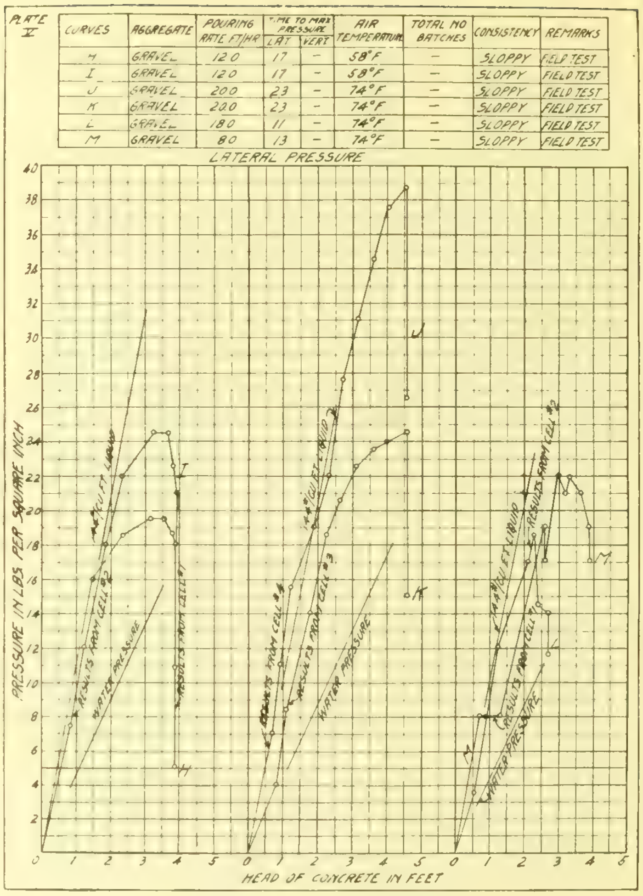


FIG. 10.—SHOWING LOCATION OF PRESSURE CELLS NOS. 3 AND 4 DURING FIELD TESTS.

Example II.—For reinforced concrete column. Mix to be 1:2:4; consistency, 8-inch slump; rate of fill to be 24 feet per hour. Total height of column and final fill, 11 feet, made in one pouring; since this is done in less than 30 minutes the value for H is 11. Substituting in the formula—

$P = 11^{0.2}24^{0.3} + (0.12 \times 17) - (0.3 \times 8)$.
$P = 3.83$ pounds per square inch.
Vertical pressure $= P + 0.25H = 6.58$ pounds per square inch.



CURVES	AGGREGATE	POURING RATE FT/HR	TIME TO MAX PRESSURE		AIR TEMPERATURE	TOTAL NO BATCHES	CONSISTENCY	REMARKS
			LAT	VERT				
H	GRAVEL	120	17	–	58°F	–	SLOPPY	FIELD TEST
I	GRAVEL	120	17	–	58°F	–	SLOPPY	FIELD TEST
J	GRAVEL	200	23	–	74°F	–	SLOPPY	FIELD TEST
K	GRAVEL	200	23	–	74°F	–	SLOPPY	FIELD TEST
L	GRAVEL	180	11	–	74°F	–	SLOPPY	FIELD TEST
M	GRAVEL	80	13	–	74°F	–	SLOPPY	FIELD TEST

FIG. 11.—FIELD TESTS.

Example III.—For dry mix, mass concrete. Mix to be 1 : 3 : 6; consistency, 3-inch slump; rate of fill 6 feet per hour; distance between sides of form, 3 feet; total height of fill within 30 minutes, 4 feet. Then,

$P = 4^{0.2}6^{0.3} + (0.12 \times 11) - (0.3 \times 3)$.
$P = 2.68$ pounds per square inch.
Vertical pressure = 4 pounds per square inch.

ALABAMA'S BOND ISSUE.

The people of Alabama, at the special election in February, adopted by a large majority the constitutional amendment permitting the issue of $25,000,000 bonds. In only one county in the State was there a majority against the amendment. On the same day Jefferson County, that State, voted in favor of an issue of $5,000,000 of bonds for highway construction.

OREGON BOND ACT.

At its special session in January of this year the Oregon Legislature passed a road-bonding act providing for $10,000,000 in bonds for State highways, a constitutional amendment permitting the issue to be submitted to the people at a special election on May 21. The proposed amendment increases the limit of the State's bonded indebtedness from 2 to 4 per cent of the assessed valuation.

PROPER CONSISTENCY OF BITUMINOUS MATERIALS IN HIGHWAY ENGINEERING

By PRÉVOST HUBBARD, Chemical Engineer.[1]

As applied to bituminous materials for use in highway engineering the term consistency is most commonly used to designate "degree of firmness," which is one of Webster's definitions of the word consistence. Both terms are very broad as applied to the physical properties actually determined by the common tests for consistency, so broad in fact that results obtained by one method can not be accurately translated into the results obtained by any other method.

Before considering these methods and their significance, it should first of all be realized that the true bitumen of bituminous highway materials is in reality a fluid, although it is called semisolid or solid when its degree of firmness passes certain arbitrary points. The one certain property of any fluid is that under certain conditions it will flow. Degree of firmness is therefore indicated by degree of fluidity, most readily determined by "resistance to flow," which is the accepted definition of the term viscosity. Most of the direct tests for determining the consistency of bituminous materials are therefore viscosity tests, although they may be made in a variety of ways.

The resistance to flow of any bituminous material is substantially influenced by the temperature of the material, a general rule being that the higher its temperature the lower becomes its resistance to flow. While this is true, the relative decrease in resistance to flow with increase in temperature is not necessarily the same for all bitumens and in fact may be widely different for different classes or types of bitumen which may show identically the same resistance to flow at a given temperature. Put in other words, some bituminous materials are more susceptible to temperature changes than others, and in general their consistency at a given temperature is no certain indication of their consistency at another temperature.

Bituminous materials may contain other material than bitumen and almost invariably, as used in highway treatment and construction, are purposely mixed or become mixed with mineral matter. The amount, character, and fineness or grading of the mineral matter may exert a tremendous influence upon the consistency of the mixture, and if the mineral particles are in sufficient quantity to be in contact their state of compaction is also an important factor. In the ultimate analysis, degree of firmness of such mixtures as they exist in the highway is the primary consideration, and selection or control of the consistency of the bitumen present is only one of a number of contributing factors in obtaining the desired degree of firmness, more often expressed as resistance to displacement of the mixture If this reasoning is correct, it is manifestly irrational to limit the consistency of a bituminous material with any greater degree of refinement than the control of other equally important factors bearing upon the resistance to displacement of the bituminous mixture.

METHODS OF DETERMINING CONSISTENCY.

Coming now to the methods determining the consistency of bituminous materials, we have first to consider the grade and type of material. So far as method of use is concerned, it is convenient to establish three general classes: (1) Materials for cold surface treatment, (2) materials for hot-surface treatment, and (3) materials for construction. The types are (1) petroleum and asphalt products and (2) tar products.

The consistency of both types for cold-surface treatment is most frequently determined and specified by a viscosity test made with the Engler viscosimeter, which is used to measure the time required for a given quantity of the material to flow through a standard tubular opening under a standard initial head. For such use the first consideration is to have the material sufficiently fluid under ordinary atmospheric conditions to insure its uniform distribution over the road surface at the proper rate per square yard according to the method of distributing. For this purpose a maximum viscosity limit should be used. For materials to be used solely as dust paliatives no minimum viscosity limit is necessary as resistance to displacement of its admixture with dust particles does not have to be taken into account. Petroleum products are used almost exclusively as dust palliatives and should be sufficiently fluid to apply by means of a gravity distributor if necessary. A maximum specific viscosity of 10 at 25° C. will insure the desired degree of fluidity, and this is the only consistency requirement which is necessary.

When a bituminous material is to be applied cold for the purpose of building up a thin mat or carpet with a cover of mineral matter the ultimate stability of such a mat becomes an important quality. With the average mineral cover of broken stone or sand no cold application material possesses the desired degree of firmness, but it should approach this characteristic as closely as possible and should develop it to the fullest extent soon after application. As in the case of dust palliatives, a maximum viscosity limit is necessary to insure that it is sufficiently fluid to be applied at normal atmospheric temperatures. When application is made by means of a pressure distributor it has been found that a maximum specific viscosity of 120 at 25° C. is about the safe limit to use in the case of oil products, and a range of from 80 to 120 specific viscosity is considered reasonable. Cut-back asphalts, which harden rapidly through loss of a relatively small amount of volatile flux, may properly be held to a very much lower range, and for this class of material the American Society for Municipal Improvements has adopted limits of from 25 to 35 specific viscosity at 25° C. The reason for this is that allowance must be made for possible hardening during handling before application is made. Thus, if a maximum of 120 specific viscosity was allowed for cut-back asphalts, unavoidable loss of volatile constituents before application might increase the consistency of the product to such an extent that it could not be successfully applied cold.

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[1] Paper read before meeting of State highway testing engineers and chemists held at Washington, Feb. 23-27, 1920.

VISCOSITY OF TAR PRODUCTS.

Tar products for cold surface treatment are seldom used for the purpose of dust laying only. For mat or carpet construction it has become customary to specify their specific viscosity at 40° C. rather than at 25° C. This is purely a matter of convenience, however, from the standpoint of testing, as the same factors govern their viscosity limits as mentioned for oil products. Tars are more susceptible to temperature changes than are the oils, and their susceptibility factors vary considerably. It has been found, however, that for tars containing not more than the usual maximum limit of 10 per cent free carbon a specific viscosity at 40° C. of over 35 is apt to cause difficulty in distribution even in warm summer weather. This limit is, therefore, the maximum that should be allowed. A safe minimum for cool weather has been found to be 10 specific viscosity at 40° C. Within these limits the American Society for Municipal Improvements recommends that a range of 5 be allowed for any one job. Limits of from 10 to 25 for cool climates and from 20 to 35 for warm climates would, however, appear to be reasonably satisfactory for ordinary use.

Tars harden with relative rapidity upon exposure under atmospheric conditions, sometimes to the extent of becoming too brittle to give long service. On the other hand, petroleum products may not harden with sufficient rapidity to produce the desired resistance to displacement in the bituminous mat. In order to insure the necessary hardening properties of the latter, a consistency requirement for the residue obtained from the volatilization test is sometimes included in specifications. Thus for oil products the United States Bureau of Public Roads specifies a minimum float test of 90 seconds at 50° C. on the residue from the volatilization test, while for cut-back asphalts the American Society for Municipal Improvements specifies a penetration at 25° C. of from 50 to 85 for such residue. The maximum limit in the latter case is to prevent the use of too hard an asphalt in the manufacture of the cut back. No maximum limit is required for petroleum products owing to the presence of nonvolatile oils, which prevent undue hardening after application.

IN HOT-SURFACE TREATMENT.

For hot-surface treatment much more viscous materials may be used than for cold-surface treatment, but they should be sufficiently fluid at the temperature of application, 95° to 130° C., to be uniformly distributed at the proper rate, and before cooling after application should be fluid enough to saturate the surface of the road and firmly adhere to it. For oil products this will require a maximum specific viscosity at 100° C. of not more than 60 if the surface treatment of gravel as well as macadam roads is to be included. All tar products of suitable normal consistency are sufficiently fluid, at the temperatures of application previously mentioned, to apply satisfactorily, so that a consistency test at such range of temperatures is unnecessary. At normal temperature both oil and tar products for hot-surface treatment should be too viscous to be conveniently tested with the Engler viscosimeter, and their consistency is probably best controlled by means of the float test at 32° C. In view of the maximum viscosity limit at 100° C. only a minimum float test at 32° C. need be specified for petroleum products without danger of securing too hard a material. For this purpose the United States Bureau of Public Roads has set a minimum float test at 32° C. of 60 seconds. The consistency of tar products for the same purpose, however, is limited by a minimum float test of 60 seconds and a maximum float test of 150 seconds at 32° C. in order to prevent the use of an undesirably soft or undesirably hard product. For reasons mentioned in discussing the cold application materials, specifications for petroleum products for hot application may include a minimum consistency requirement for the residue from the volatilization test. This limit may reasonably be somewhat higher, as illustrated by the United States Bureau of Public Roads specification in which the residue is required to show a float test at 50° C. of not less than 110 seconds, thus insuring a material which will harden after application.

USE OF BITUMINOUS MATERIALS.

Bituminous materials for highway construction are used according to the penetration method or the mixing method to coat the particles of mineral aggregate of the pavement throughout a depth of seldom less than 2 inches. In the former case the material is applied to the pavement proper and while still hot must flow between the mineral fragments to the required depth and coat the exposed surfaces. Upon coming in contact with the broken stone a portion of it almost immediately congeals on the cold surfaces. The coatings of bitumen are therefore relatively thick as compared with coatings produced by the mixing method of construction. Stability of such pavements commonly known as bituminous macadam depends to a very great extent upon the interlocking of the large mineral fragments. Under traffic there is, however, more or less internal movement, so that eventually the bituminous material finds its way between the corners, edges, and surfaces in actual contact, although the coatings at such places are necessarily squeezed thinner than at other places. For this reason the bituminous cement should be sufficiently hard under conditions of service to prevent it from acting as a lubricant. On the other hand, it should be sufficiently soft to heal fractures or displacements due to internal movement. These factors are of such importanceas to warrant limits of consistency based upon general climatic conditions to which the pavement will be subjected.

Because of the fact that tars harden materially after use they are required to be of softer original consistency than are the asphalt cements used for a similar purpose. They should be so soft in fact that they can not be tested by means of the penetration test made in the usual manner. Their consistency is usually specified by a float test at 50° C., which is approximately the maximum temperature the pavement is likely to attain. For general low-temperature conditions a float test at 50° C. of from 120 to 150 seconds is commonly specified and for high temperature conditions these limits are raised to from 150 to 180 seconds.

CONSISTENCY OF ASPHALT CEMENT.

Owing to their rapid hardening, especially when existing in thin films, and to their high susceptibility to temperature changes, tars are now seldom used in the mixed types of construction. Asphalt cements are almost exclusively used for such types, and as selection of their consistency limits for asphalt macadam, the various classes of asphaltic concrete, sheet asphalt, and other mixed types, involves many considerations common to all, they may best be considered collectively.

What may be termed the normal consistency of asphalt cements is determined and specified by means of the penetration test, the factors of temperature, loading, and time being 25° C., 100 grams, 5 seconds. In this test, degree of firmness is determined by recording the distance that a standard needle penetrates a sample of the material under the above-mentioned conditions of temperature, loading, and time.

While certain rather wide limits of normal penetration have been found to describe suitable consistencies of asphalt cements for the various types of construction, no absolute standards of limits have been generally adopted for each type under accurately defined temperature and traffic conditions. It is recognized, however, that for any given type under otherwise similar conditions the warmer the climate the lower should be the normal penetration of the asphalt cement. In like manner, considering traffic as the only variable, it is recognized that the heavier the traffic the lower should be the penetration of the asphalt. As far as the types themselves are concerned, for all sheet or continuous forms of construction in which only a relatively small percentage of mineral particles pass the 200-mesh screen, it is also recognized that the finer the aggregate the lower should be the penetration of the asphalt cement. In connection with this statement, fineness of aggregate is meant to imply a weighted average diameter of fragment.

CLIMATE AND TRAFFIC CONDITIONS.

At the present time climatic and traffic conditions with reference to highways are dealt with under very broad general terms, which unfortunately do not always have the same significance in the minds of different individuals, owing to the fact that the terms are merely relative. Thus the terms low, moderate, and high are used to describe general temperature conditions. To the average mind it would seem that low temperature conditions might imply climates in which the winters are long and severe while the summers are relatively short and temperate. Moderate temperature conditions would also seem to imply climates in which neither winters nor summers are as a rule severe. On the other hand, high temperature conditions imply climates in which the summers are long and hot and the winters short and mild. There are, of course, certain localities where extremes of both winter and summer temperatures prevail for short periods, in which case an average of moderate temperature is reasonably safe to assume for the purpose of selecting suitable consistency for a bituminous material. Another method of classifying climate which is really based upon the factors just mentioned is to divide the United States into three belts or zones—northern, middle, and southern—the general temperature conditions of which are assumed to be low, moderate, and high, respectively. It will be found, however, that it is impossible to accurately bound these three zones with any parallels of latitude, as in many individual instances a locality within one zone will have a climate similar to the general climatic conditions of one of the other zones. Everything considered, therefore, the terms low, moderate, and high may perhaps be preferable.

Terms commonly used to designate traffic conditions are just as broad as those used to denote temperature. In spite of the large amount of work on traffic classification, no satisfactory basis of classifying mixed traffic in units has as yet been devised. The terms light, moderate, and heavy are therefore commonly used. In general, light traffic signifies traffic in which the average load is relatively light and the number of vehicles passing per day is relatively small, such conditions prevail on most residential streets in cities and towns and on feeders to main State and county highways. The term moderate implies a somewhat more intense traffic than that just described, but one in which the average load is either not much heavier than that of a touring car, or if heavier does not occur in sufficient numbers to develop intense traffic. Many business streets in small towns, residential thoroughfares, park drives, main county highways, and State highways carrying principally tourist traffic fall in this class. The term heavy is used to designate both weight of average load and high intensity. Thus the principal business streets in towns and cities where trucking prevails or where the traffic is congested are said to carry heavy traffic. Many streets in shopping districts, boulevards, and main State highways also fall within this class.

ASPHALT PENETRATION LIMITS.

Based upon the factors of climate and traffic just described, the Asphalt Association has published a table of penetration limits for asphalt cements to be used in various types of highway construction. This table is offered merely as a suggestion or guide to engineers in connection with the insertion of suitable penetration limits in a specification for asphalt cement which has been recently adopted by the association. As it is probably the most detailed table which has been published, it is here presented for the purpose of inviting discussion:

Type of pavement.	Traffic.	Temperatures.		
		Low.	Moderate.	High.
Asphalt macadam	Light	120–150	90–120	80–90
	Moderate	90–120	90–120	80–90
	Heavy	80– 90	80– 90	80–90
Asphaltic concrete (coarse graded)	Light	70– 80	70– 80	60–70
	Moderate	70– 80	70– 80	60–70
	Heavy	60– 70	60– 70	60–70
Asphaltic concrete (fine graded)	Light	60– 70	60– 70	50–60
	Moderate	60– 70	60– 70	50–60
	Heavy	50– 60	50– 60	50–60
Sheet asphalt	Light	50– 60	50– 60	40–50
	Moderate	50– 60	50– 60	40–50
	Heavy	40– 50	40– 50	30–40
Asphalt block	Light	15– 25	15– 25	10–15
	Moderate	15– 25	15– 20	10–15
	Heavy	15– 20	10– 15	5–15

In connection with particular ranges of penetration, the Asphalt Association recommends that in any event a 10-point limit be allowed for asphalt cement of less than 90 penetration and that a 30-point limit be allowed for asphalt cement of over 90 penetration. Such limits may readily be met under ordinary manufacturing conditions and are sufficiently close to insure uniformity in connection with other requirements of the specifications. It will be noted that the limits apply only to the normal conditions of test, no requirements being included for penetrations at 0° C. or at 46° C. It is believed that with the materials now on the market penetration requirements at temperatures other than 25° C. are unnecessary, provided the 10 or 30 point range is adhered to as recommended. So far as actual consistency of the asphalt cement is concerned, when the temperature of the highway is 25° C., it is evident that the limits are unnecessarily close, considering the ordinary susceptibility of asphalt cements to temperature changes. Such limits are, however, advisable in order to insure that the product will not become too hard in cold weather nor too soft in hot weather. If the limits were materially increased, then requirements of penetration at either 0° C. or 46° C., or both, might be advisable, according to climatic conditions under which the material would be in use.

In connection with this table it is of interest to note that the penetrations of asphalt cement for asphalt block are very much lower than for any of the other types of pavement. This is allowable for two reasons, irrespective of the usual grading of the aggregate, which in itself would not warrant such low penetrations. In the first place, a blown type of asphalt is specified for asphalt block, a ductility requirement of from 5 to 8 being made. Such asphalts are less susceptible to temperature changes than the more ductile products specified for the other types of construction, and do not become relatively as hard in cold weather. In the second place, in asphalt block construction, prevention of contraction cracks does not have to be considered as in the case of the sheet types of construction. The necessity of using a harder asphalt cement than for the sheet types exists because of the fact that after manufacture the blocks must withstand rather rough handling during shipment and prior to laying without distortion or breakage.

TABLE SUGGESTION, NOT STANDARD.

While in general the table of limits takes into account fineness of mineral aggregate in so far as classification by types of construction is concerned, ordinary grading requirements for any one type are usually so broad that certain gradings within specification requirements may make it advisable to adopt a higher or a lower range of penetration limits for a given combination of climatic and traffic conditions than the range shown in the table. For this reason the table has been offered more in the way of suggestion than for adoption as standard. It is practically impossible to define the most suitable penetration limits for every conceivable grading which is acceptable, but fortunately experience has already demonstrated to many engineers who are obliged to use certain aggregates, such as sand from a given deposit, what penetration limits are best to use. In any event necessity of a marked departure from the limits recommended is not apt to exist.

When most of the aggregate passes the 200-mesh sieve and consists of clayey material, as in the case of asphalt-earth mixtures, the general rule that penetration of asphalt cement should decrease with fineness of the aggregate does not appear to hold true. Such an aggregate has an enormous surface area as compared with aggregates of other types of construction, and when coated with films of asphalt cement possesses such high surface friction as to create very considerable resistance to displacement. A softer asphalt cement may therefore be used than for the coarser aggregates such as sheet asphalt or Topeka. Penetrations of 90 or 100 have been successfully used under such conditions. The use of a relatively soft asphalt cement is, moreover, desirable because of the fact that asphalt-earth mixtures are not as susceptible to the kneading action of traffic and means must therefore be provided for internal adjustment to meet the tendency to crack in cold weather due to contraction of the pavement.

THE AGGREGATE AS A FACTOR.

One factor bearing upon the proper consistency of bituminous materials which was mentioned in the first part of this paper is often of considerable importance. This is the character of the aggregate. Most aggregates composed of fragments in which quartz, feldspar, and other hard minerals predominate require asphalt cements of about the penetration ranges shown in the table. When the fragments are of soft limestone, however, the use of softer asphalt cements than indicated may be proper. Thus in the construction of asphalt macadam roads with the very soft coraline rock of Florida, an asphaltic oil ordinarily suitable only for hot surface treatment may be used successfully as a binder. This would not be practicable with the harder rocks. The reason lies in the fact that the fine limestone dust which is worn off of the larger fragments amalgamates with the asphalt films to form a tough mastic of higher frictional resistance than the asphalt itself. This property, possessed also by Portland cement, is utilized in the manufacture of paving mixtures where limestone dust or Portland cement is incorporated as filler. The presence of filler toughens the mix and produces a mixture less susceptible to temperature changes.

The proper consistency of asphalt fillers for brick and block construction depends mainly upon climatic conditions and how the filler is used. For poured or squeegeed joints a partially blown type of asphalt has been adopted by the Asphalt Association with a minimum penetration requirement of 10 when tested at 0° C., under a load of 200 grams for one minute. This is to prevent the filler from becoming too brittle in cold weather. Normal penetration limits of from 40 to 50 for low temperature conditions and from 30 to 40 for high temperature conditions are suggested. In order that the filler may not become unduly soft and bleed in warm weather, a minimum melting point of 65° C. (ring and ball) is specified. A maximum melting point of 100° C. is also specified in order to insure its workability at the temperature of application and to allow sufficient time for it to flow into the joints before is congeals.

When a filler is to be applied as a grout after being mixed with hot sand, an unblown asphalt cement has been used with satisfactory result. Because of the fact that the sand materially stiffens the filler, it may be softer than the poured filler and a 20-point penetration limit at normal temperature is believed to be sufficiently close for all practical purposes. For low temperature conditions such a limit between 70 and 100 is suggested, while limits of 50 to 70 are suggested for high temperature conditions. Such ranges prevent the grout from becoming too brittle in cold weather and from bleeding in warm weather.

In order that asphalt cements may not be injuriously hardened when they are heated up to and maintained for reasonable periods at the maximum temperature of application, it has become customary to specify that the residue from the volatilization test at 163° C. shall show a penetration of not less than 50 per cent of the penetration of the original material. This is merely a precautionary requirement however as under ordinary conditions of heating in practice no asphalt cement will harden to anywhere near this extent.

SERVICE RESULTS AS GUIDES.

After all, the best guide to selection of the proper consistency of bituminous materials is experience, and it is upon service results rather than upon theoretical considerations that most of the consistency limits have been selected. Service results may, however, sometimes be misleading in this connection, and other factors than consistency should receive due consideration in attempting to analyze such results. Thus the use of too soft a bituminous material may result in the pavement shoving under traffic and also bleeding. The use of an excess of bituminous material of proper consistency may, however, cause both defects. Shoving may also be caused by lack of compaction or poor grading of the aggregate. The use of too hard a bituminous material promotes cracking of the pavement and sometimes causes it to break up or disintegrate under traffic. An insufficient quantity of material of suitable consistency, poor aggregate grading, and poor compaction may also cause these defects. Overheating or burning the bituminous material may also be responsible.

In conclusion, there appear to be at least two promising and useful lines of investigation in connection with the consistency of bituminous materials: (1) Working out a method of expressing consistencies in comparable form for all ranges from very fluid to practically solid, and (2) devising a method for accurately determining the consistency or resistance to displacement of compacted bituminous aggregates.

FEDERAL-AID ALLOWANCES

PROJECT STATEMENTS APPROVED IN FEBRUARY, 1920.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Alabama	72	Montgomery	4.420	Gravel, surface treatment	Feb. 12	$36,342.07	$18,171.03
Arizona	21	Coconino	1.105	High class, undetermined	Feb. 24	60,258.00	25,000.00
Do	15	Gila and Graham	55.833	Earth	Feb. 27	618,604.25	309,302.12
Arkansas	53	Crittendon	13.730	Gravel	Feb. 12	107,975.89	30,000.00
Do	60	Yell	32.530	Bituminous macadam	Feb. 16	318,772.30	130,000.00
California	44	Yolo	10.710	Reinforced concrete	do	285,021.00	142,510.50
Do	46	Humboldt	17.960	do	do	424,363.50	212,181.75
Do	47	Mariposa	9.390	Earth	Feb. 19	641,927.00	198,140.00
Colorado	91	Los Animas	11.362	Gravel	Feb. 12	59,488.00	29,744.00
Do	34	Weld	2.080	Concrete	Feb. 16	74,983.31	37,491.65
Do	64	Costilla	7.888	Earth	do	29,706.82	14,853.41
Georgia	130	Baldwin		Bridge	Feb 12	40,029.95	20,000.00
Do	123	Grady		do	Feb. 16	36,239.50	18,119.75
Indiana	17	Lake, Porter, and Laporte	[1]16.800	Brick, concrete, or bituminous macadam.	do	[1]676,726.60	[1]336,000.00
Do	9	Johnson	[2]31.280	do	do	[1]1,019,409.60	[1]509,705.00
Iowa	40	Muscatine	20.590	Earth	Feb. 12	46,604.25	23,300.00
Do	45	Mitchell	15.880	Gravel	do	101,966.70	55,900.00
Do	47	Tama	30.000	Earth	do	115,890.50	57,900.00
Do	53	Louisa	23.400	do	do	132,682.00	66,300.00
Do	58	Benton	17.890	High class, undetermined	do	380,939.52	190,400.00
Do	66	Kossuth	34.230	Earth	do	121,594.00	60,700.00
Do	70	Mahaska	27.760	do	do	159,060.00	79,500.00
Do	81	Taylor	19.250	do	do	142,780.00	71,300.00
Do	90	Iowa	26.200	do	do	123,090.00	61,500.00
Do	96	Linn	12.750	do	do	45,391.50	22,600.00
Do	99	Carroll	8.880	do	do	82,940.00	41,400.00
Do	103	Delaware	13.300	Gravel	do	95,942.00	47,900.00
Do	110	Lyon	23.000	Earth	do	69,800.50	34,900.00
Do	116	Cherokee	14.000	do	do	43,912.00	21,900.00
Do	19	Grundy	14.300	do	Feb. 16	53,075.00	26,500.00
Kansas	45	Saline	7.000	Pavement	Feb. 14	477,433.00	105,000.00
Do	44	do	5.250	do	Feb. 16	412,568.20	78,750.00
Do	47	Chase	3.790	do	Feb. 21	239,378.37	56,250.00
Kentucky	20	Breathitt	6.500	Earth	Feb. 12	180,627.48	90,313.74
Louisiana	27	Rapides	19.810	Gravel	Feb. 21	279,840.61	139,920.30
Do	62	Beauregard	35.930	do	do	471,194.46	200,000.00
Maryland	2	Prince Georges	[1].780	Concrete	Feb. 4	[2]12,433.07	[2]8,568.25
Do	6	do	[1]3.380	do	do	[2]81,479.85	[2]40,739.92
Do	7	do	[1]32.121	do	do	[1]134,587.52	[1]68,406.89
Do	8	Talbot	[1]9.990	do	do	[1]353,774.30	[1]176,887.15
Do	9	Frederick	[1]3.500	do	do	[1]109,799.47	[1]54,899.74
Do	10	Montgomery	[1]6.175	do	do	[1]162,394.98	[1]86,550.00
Do	13	Prince Georges	3.020	do	do	[1]98,257.30	[1]49,128.65
Do	15	Baltimore	3.330	do	do	[1]125,409.02	[1]62,704.51
Do	17	Harford	1.900	do	do	[1]71,308.72	[1]35,954.36
Do	22	Caroline	2.564	do	do	[1]127,043.65	[1]59,499.33
Do	24	Allegany	.820	do	do	[1]14,752.12	[1]16,400.00
Do	25	Charles	4.000	Gravel	do	[1]89,327.81	[1]44,663.91
Do	28	Anne Arundel	9.747	Concrete	do	[1]470,509.82	[1]194,935.60
Do	29	Worcester	4.550	do	do	[3]176,000.00	[3]88,000.00
Do	30	do	2.400	do	do	[1]107,917.92	[1]53,958.96
Do	31	Charles	5.180	Gravel	do	[1]119,273.77	[1]59,636.89
Do	33	Carroll	4.790	Concrete	do	[1]197,872.46	[1]98,936.24
Do	34	Anne Arundel	.910	Gravel	do	[1]70,902.92	[1]35,451.46
Do	35	Washington	7.49	Concrete	do	[1]266,542.43	[1]133,271.22
Do	37	Kent and Queen Annes	17.000	do	do	[1]598,816.46	[1]299,408.23
Massachusetts	31	Essex	1.107	Bituminous macadam	Feb. 16	45,544.87	22,140.00
Do	32	Hampshire	3.078	do	do	172,778.37	86,389.18
Michigan	26	Antrim	7.831	Gravel	Feb. 19	119,625.00	59,812.50
Do	40	Barry	3.441	do	do	57,552.00	28,776.00
Minnesota	109	Redwood	22.500	do	Feb. 16	44,550.00	22,275.00
Do	144	Red Lake	8.000	do	do	75,680.00	37,840.00
Do	148	Hennepin and Dakota	11.670	do	do	318,233.08	159,116.54
Do	124	Isanti	6.620	do	Feb. 19	72,377.94	36,188.97
Mississippi	26	Amite	[3]7.860	Clay, gravel	Feb. 16[3]	[3]22,643.50	[3]10,000.00
Missouri	42	Barry and Lawrence	10.430	Gravel	Feb. 16	44,066.00	22,033.00
Do	74	Cedar	10.620	do	do	30,744.00	15,372.00
Do	81	Jasper	2.600	Concrete	do	79,425.50	39,712.75
Do	82	do	7.600	do	do	31,277.40	15,638.70
Do	83	Jasper and Newton	9.500	do	do	227,999.97	113,999.98
Do	84	Jasper	6.600	do	do	231,137.50	115,568.75

[1] Modified agreements. Amounts given are decreases over those in the original agreements.

[2] Modified agreements. Amounts given are increases over those in the original agreements.

[3] Statements canceled or withdrawn.

PROJECT STATEMENTS APPROVED IN FEBRUARY, 1920—Continued.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Missouri	85	Taney	4.763	Gravel	Feb. 16	$23,999.06	$11,999.53
Do	86	Hickory	4.540	do	do	25,424.00	12,712.00
Do	87	Henry	5.160	Concrete	do	125,387.70	62,693.85
Do	88	Cedar	7.480	Gravel	do	22,976.00	11,488.00
Montana	83	Valley	2.000	do	Feb. 12	13,970.00	6,985.00
Do	80	Blaine		Bridge	Feb. 18	14,999.99	7,499.99
Do	81	do		do	do	9,147.60	4,573.80
Do	69	Jefferson	.730	Pavement	Feb. 19	24,392.50	12,196.25
Nebraska	111	McPherson	11.500	Earth	Feb. 12	50,160.00	25,080.00
Do	140	Custer	11.800	do	do	37,345.00	18,672.50
Do	126	Hitchcock and Hayes	26.900	Sand-clay	Feb. 16	88,622.60	44,311.00
Do	84	Greeley	15.200	do	do	42,680.00	21,340.00
Do	128	Seward and Lancaster	29.100	Earth	Feb. 19	94,545.00	47,272.50
Do	137	Keyapaha and Rock	26.300	Sand-clay	do	148,566.00	74,283.00
Do	136	Pierce	33.300	Earth	Feb. 21	124,649.80	62,324.90
Do	91	Washington	[1] 3.380	do	Feb. 19		
New Mexico	43	Torrence	17.000	do	Feb. 16	52,360.00	26,180.00
Do	41	Otero	18.000	Gravel	do	57,710.12	28,855.06
Do	45	Luna	5.380	do	Feb. 19	32,892.75	16,446.37
New York	46	Dutchess	2.500	Reinforced concrete	Feb. 21	100,000.00	50,000.00
North Carolina	117	Wilson	6.200	Sand-clay	Feb. 19	48,796.00	24,398.00
Do	119	Bladen	23.000	do	do	164,153.00	82,076.50
Do	120	do	23.000	do	do	157,740.00	78,870.00
Do	115	Henderson	10.000	do	Feb. 24	100,903.20	50,451.60
Do	124	Surry	18.000	do	do	141,644.80	70,822.40
Do	86	Martin and Bertie	3.900	do	Feb. 21	427,072.80	213,536.40
North Dakota	104	Hettinger		Bridge	Feb. 16	15,400.00	7,700.00
Do	105	do		do	do	19,800.00	9,900.00
Oklahoma	25	Kingfisher	1.485	Pavement	Feb. 12	59,424.79	29,712.39
Do	28	Woods and Woodward		Bridge	Feb. 14	152,000.00	76,000.00
Do	26	Grant		do	Feb. 19	121,528.00	60,764.00
South Carolina	73	Spartanburg	12.636	Sand-clay	do	151,189.89	50,000.00
Do	84	Laurens	14.131	do	do	84,863.19	25,000.00
Do	36	Chesterfield	11.346	do	Feb. 21	85,358.47	24,000.00
South Dakota	47	Lincoln	15.000	Gravel	Feb. 16	122,200.10	61,100.05
Do	41	Marshall and Roberts	24.400	do	Feb. 19	178,476.10	89,238.05
Do	44	Roberts	10.400	do	do	80,173.50	40,086.75
Do	48	Moody	3.850	do	do	34,729.20	17,364.60
Do	50	Sanborn	12.000	do	Feb. 21	104,060.00	52,030.00
Do	37	Faulk and Potter	13.000	Earth	do	70,697.00	35,348.50
Do	38	Jerauld	16.800	Gravel	do	104,995.00	52,497.50
Do	52	Minnehaha	10.250	do	do	96,071.80	48,035.90
Do	53	Miner and Lake	11.000	do	do	85,013.50	42,506.75
Do	45	Grant	13.900	do	do	141,267.50	70,633.75
Do	26	Kingsbury	[2] .590	do	do	[1] 970.20	[1] 485.10
Tennessee	30	Tipton	5.152	Bituminous macadam	do	148,305.74	74,152.87
Do	42	Hamblen	8.314	do	do	180,355.11	90,177.55
Texas	135	Schleicher	30.000	Water-bound macadam	Feb. 12	194,999.97	85,000.00
Do	141	Polk	20.000	Gravel	do	153,395.00	38,348.75
Do	134	do	40.000	Gravel treatment	Feb. 14	609,257.00	152,314.25
Do	133	Kimble	34.900	Gravel	Feb. 19	200,184.72	100,000.00
Do	144	Nacogdoches	18.640	do	do	233,774.47	58,443.61
Do	147	Smith	24.600	do	do	244,915.00	112,742.76
Do	146	Delta	11.310	do	Feb. 21	306,500.50	95,000.00
Do	148	Klebing	19.640	do	do	429,999.89	125,000.00
Do	1	Culberson	[3] 50.400	Earth	Feb. 27	[3] 45,265.55	[3] 22,632.77
Do	47	Collingsworth	[3] 10.500	Sand-clay	Feb. 6	[3] 10,010.00	[3] 5,000.00
Utah	11	Iron	33.300	Gravel	Feb. 16	331,328.02	165,664.01
Vermont	14	Windham	5.600	do	do	122,003.20	61,001.60
Virginia	74	Princess Anne	10.880	Concrete	do	364,870.00	182,435.00
Washington	50	Spokane	4.110	do	Feb. 21	159,921.30	79,960.65
West Virginia	77	Greenbrier	6.750	Bituminous macadam	Feb. 16	66,500.00	29,191.40
Wisconsin	173	Rusk	1.020	Earth	Feb. 14	9,326.37	3,300.96
Do	161	Juneau	0.935	Concrete	Feb. 16	29,986.66	10,086.83
Do	171	Richland		Bridge	do	29,581.20	10,427.07
Do	126	St. Croix	2.750	Concrete	Feb. 19	92,560.94	33,360.00
Do	108	Juneau	1.630	Earth	Feb. 21	27,891.78	11,547.00
Do	111	Eau Claire	1.890	Reinforced concrete	do	75,753.15	28,253.00
Do	172	Richland	3.500	Earth	do	50,400.00	18,000.00
Wyoming	40	Niobrara	11.894	do	Feb. 10	35,640.00	17,820.00
Do	55	Uinta	4.012	Gravel	Feb. 16	27,445.00	13,722.50
Do	56	Converse	7.224	Sand-clay	do	38,874.00	19,437.00
Do	59	Carbon	28.608	Earth	do	103,015.00	51,507.50
Do	60	do	2.384	Sand-clay	do	11,110.00	5,555.00
Do	49	Sweetwater	43.920	Earth	Feb. 24	164,670.00	82,335.00
Do	46	Laramie	25.304	Sand-clay	Feb. 21	93,280.00	46,640.00
Do	13	Carbon	[3] 13.880	Earth	Feb. 7	[3] 14,500.75	[3] 7,250.37

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[1] Revised statements. Amounts given are decreases over those in the original statements.
[2] Modified statements. Amounts given are increases over those in the original statements.
[3] Statements canceled or withdrawn.

PROJECT AGREEMENTS EXECUTED IN FEBRUARY, 1920.

State.	Project No.	County.	Length, in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Alabama	57	Jefferson	5.670	Sheet asphalt	Feb. 19	$255,085.42	$113,400.00
Do	61	Crenshaw	11.113	Sand-clay	do	39,257.84	19,252.29
Do	67	Dale	22.290	do	do	139,800.66	69,900.33
Do	65	Pike	8.810	do	Feb. 2	52,853.84	26,426.91
Do	38	Lawrence		Gravel	Feb. 14	[1] 10,838.08	[1] 5,419.04
Do	37	Jackson		do	Feb. 16	[1] 1,814.26	[1] 907.13
Do	17	Greene		do	Feb. 10	[1] 35,622.86	[1] 17,811.43
Arizona	2	Maricopa		Concrete	Feb. 19	[1] 1,362.90	[1] 7,971.41
California	35	San Diego	13.800	Earth	Feb. 18	224,649.11	112,324.55
Do	33	San Bernardino and Riverside	7.100	do	do	107 054.79	53,527.39
Do	34	San Diego	6.610	do	do	78,399.01	39,199.52
Do	32	Siskiyou	17.040	Concrete	Feb. 26	422,063.13	211,031.56
Colorado	62	Otero	0.833	do	Feb. 19	29,011.40	14,505.70
Do	63	do	0.843	do	do	27.905.35	13,952.67
Georgia	53	Bibb	2.140	do	Feb. 6	74,644.02	37,322.01
Do	46	do	8.700	do	Feb. 17	263,645.58	131,822.79
Do	33	Troup		Sand-clay	Jan. 29	[1] 20,985.31	[1] 8,000.00
Do	6	Hall and Lumpkin	10.352	Gravel	Feb. 10	[1] 5,691.82	[1] 2,845.91
Illinois	8C	Sangamon Madison, Macoupin	5.684	Concrete	do	190,563.91	95,281.95
Do	8H	do	5.678	do	do	211,965.26	105,982.63
Do	SP15d	do	4.641	do	do	167,982.94	83,991.47
Do	8Q	do	2.749	do	do	111,926.49	54,980.00
Do	8S	do	4.813	do	do	199,598.82	96,260.00
Do	8U	do	3.749	do	do	148,020.90	74,010.45
Do	W.15d	do	5.033	do	do	168,357.27	84,178.63
Do	8Y	do	4.029	do	do	175,006.27	82,416.09
Iowa	104	Polk	6.570	Pavement	Feb. 24	339,418.20	131,000.00
Do	39	Greene	7.410	do	do	302,539.82	148,200.00
Maine	3	Kennebec		Bituminous macadam	Feb. 10	[1] 75,189.15	[1] 73,945.22
Maryland	28A	Anne Arundle	0.753	Concrete	do	35,490.18	15,064.40
Do	31	Charles	2.020	Gravel	do	23,726.23	11,863.11
Do	35	Washington	2.010	Sheet asphalt	Feb. 19	65,107.57	32,553.78
Do	32	St. Marys	5.850	Gravel	do	76,882.30	38,441.15
Do	30	Worcester	1.900	Concrete	do	61,482.08	30,741.04
Do	13B	Prince Georges	0.830	do	Jan. 31	38,066.60	19,033.30
Do	13A	do	0.190	do	Feb. 12	[2] 6,264.44	[2] 3,132.22
Massachusetts	27	Essex	1.766	Bituminous, concrete, and macadam	Feb. 19	45,512.17	22,756.08
Do	5	Berkshire		Water-bound macadam	Jan. 19	[1] 40,247.35	[1] 26,816.30
Michigan	32	Van Buren and Allegan	7.039	Concrete	Feb. 11	218,600.47	109,300.23
Do	18	Grand Traverse	3.113	Gravel	Feb. 16	45,978.58	22,989.29
Minnesota	24	Morrison	11.959	do	Feb. 10	50,195.84	25,000.00
Do	31	Kandiyohi	0.739	Earth and concrete	Feb. 19	[1] 248,281.47	[1] 125,000.00
Mississippi	86	Lincoln	3.610	Gravel	do	61,214.54	30,607.27
Montana	40	Gallatin	2.840	do	Feb. 18	23,017.28	11,508.64
Do	8	Meagher	9.830	Earth	Feb. 19	29,437.32	14,718.66
Do	53A	Yellowstone	26.040	Gravel	do	121,325.08	60,662.54
Do	9A	Madison	5.500	Earth	do	16,098.00	8,049.00
Do	3	Carbon		Gravel	do	[1] 2,999.14	[1] 1,499.57
Nebraska	50AB	Merrick and Nance	19.700	Sand-clay	Feb. 16	88,226.23	44,113.11
Do	100	Douglas	10.290	Earth	Feb. 3	60,379.85	30,189.92
Do	67A	Red Willow	4.560	do	Feb. 18	25,724.79	12,862.39
Do	16	Kimball and Banner	26.640	do	Feb. 19	101.883.50	50,941.75
Do	78	Douglas	12.830	do	Feb. 16	88,142.25	44,071.12
Nevada	25	White Pine	.280	do	Feb. 19	8,255.22	4,127.61
Do	1	Humboldt		Gravel	do	[1] 42,516.82	[1] 21,258.41
New Hampshire	51	Cheshire		Bituminous macadam	Feb. 4	[1] 1,079.76	[1] 539.88
New Jersey	18	Mercer	1.648	Concrete	Feb. 18	85,750.44	32,960.00
North Carolina	29	Union	8.660	Sand-clay	Feb. 11	49,535.34	24,767.67
Do	67A	Nash	5.000	Pavement	do	202,768.01	101,384.00
Do	54	Wake	6.811	Concrete	Feb. 19	249,585.19	124,792.59
Do	34	Wayne		Bridge	Feb. 10	39,982.73	10,000.00
Do	25	Persoñ		Sand-clay	do	[1] 16,105.76	[1] 8,052.88
North Dakota	38	Hettinger	8.880	Earth	Feb. 19	29,374.99	14,687.49
Do	20	Wells		do	Feb. 16	[1] 8,620.33	[1] 4,310.16
Ohio	34	Erie	3.051	Reinforced concrete	Feb. 19	113,000.00	30,000.00
Do	35	Portage	8.483	Water-bound macadam	do	224,000.00	84,700.00
Do	86	Paulding	2.019	Concrete	Feb. 27	61,700.00	20,000.00
Do	96	do	2.023	do	do	62,000.00	20,000.00
Oregon	29	Coos and Douglas	14.170	Earth	Feb. 25	387,301.99	193,650.99
South Carolina	23	Greenville	3.030	Bituminous macadam	Feb. 10	52,137.92	26,068.96
Do	33	Beaufort		Bridge	Jan. 28	20,759.20	10,379.60
South Dakota	2	Lincoln	9.970	Gravel	Feb. 19	71,842.03	35.921.01
Do	22	Day	28.070	do	do	237,379.51	118,689.75
Do	24	Hanson	27.363	do	do	173,657.83	86,828.91
Tennessee	15	Madison		Bridge	Feb. 17	22,797.39	11,398.69
Texas	68	Gonzales	27.710	Gravel	Feb. 19	233,053.84	79,473.31
Virginia	39	Buckingbam	6.264	Sand-clay	Feb. 18	57,036.43	28,518.21
Do	33	Nelson		Water-bound macadam	do	[1] 3,172.40	[1] 1,586.20
Washington	18	Skagit	5.580	Earth	Feb. 19	66,142.62	33,071.31
Do	46	Garfield	10.810	Gravel	do	202,402.72	101,201.36
Do	48	Ferry	1.190	Earth	do	23,639.77	11,819.88
Do	17	Columbia	6.570	Crushed rock	Feb. 24	104,702.64	52,351.32
West Virginia	26	Lincoln	2.360	Concrete	Feb. 2	52,899.00	26,449.50
Do	44	Mercer	4.710	Water-bound macadam	do	122,961.79	61,480.89
Do	48	Boone	5.023	Earth	Feb. 19	79,900.00	33,000.00
Do	51	Wayne		do	do	[1] 22,626.45	[1] 11,313.15
Wisconsin	78	Pepin	1.493	Gravel	do	11,683.59	3,894.53
Do	16	do	2.340	do	do	25,156.76	8,385.59
Do	2	Manitowoc	1.560	Concrete	Feb. 12	[1] 20,064.62	[1] 6,688.21

[1] Modified agreements. Amounts given are increases over those in the original agreements.
[2] Modified agreements. Amounts given are decreases over those in the original agreements.

TESTS OF ROAD-BUILDING ROCK IN 1919

CONTINUING the practice inaugurated last year, Public Roads publishes this month the physical tests of road-building rock made in the laboratories of the Bureau of Public Roads from January 1, 1919, to January 1, 1920.

The results of all tests made up to January 1, 1916, were published in Department of Agriculture Bulletin No. 370, entitled "The Results of Physical Tests of Road-Building Rock;" those made during 1916 and 1917 were reported in Bulletin No. 670; volume 1, No. 11, of Public Roads, issued in March, 1919, contained the results of the 1918 tests; and the following tables contain the test data on samples received since that time up to January 1, 1920.

Results of physical tests of road-building rock from the United States and Canada, Jan. 1, 1919, to Jan. 1, 1920.

Serial No.	Town or city.	State and county.	Name of material.	Crushing strength, pounds per square inch.	Weight per cubic foot, pounds.	Absorption, pounds per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.
		ALABAMA.								
14450	(1)	Calhoun	Quartzite schist	(2)	164	0.38	4.4	9.1	18.7	19
		ARIZONA.								
14119	Douglas	Cochise	Copper slag	(2)	217	.58	5.5	7.3	(2)	9
15296	(1)	Coconino	Calcareous sandstone	(2)	134	8.41	23.3	1.7	.0	2
15297	(1)	do	Siliceous limestone	(2)	153	4.20	7.9	5.1	18.7	6
15298	Grand Canyon	do	Chert	(2)	120	4.50	13.7	2.9	(2)	(2)
15299	(1)	do	Dolomite	(2)	162	2.28	5.0	8.0	15.0	6
13977	Globe	Gila	Copper slag	(2)	221	1.28	3.2	12.5	(2)	(2)
13978	do	do	do	(2)	220	1.43	3.1	12.9	(2)	(2)
14746	do	do	do	(2)	216	1.75	6.8	5.9	15.0	9
15190	Clifton	Greenlee	do	(2)	207	.37	4.5	8.9	18.0	27
		ARKANSAS.								
15386	(1)	Franklin	Sandstone	(2)	158	2.26	5.1	7.8	17.0	11
14425	(1)	Independence	Crystalline limestone	(2)	166	.60	10.4	3.8	8.3	3
14883	Penters Bluff	do	Chert	(2)	157	2.04	10.8	3.7	(2)	(2)
14885	do	do	Limestone	(2)	166	.67	5.4	7.4	15.3	7
14886	do	do	do	(2)	167	.69	10.5	3.8	7.3	3
14665	Lamar	Johnson	Feldspathic sandstone	(2)	156	2.51	3.5	11.4	(2)	(2)
14959	do	do	do	(2)	(2)	(2)	(2)	(2)	18.0	14
14279	Little Rock	Pulaski	Syenite	(2)	156	1.23	5.0	8.0	18.7	8
14280	16 miles west of Little Rock.	do	Sandstone	(2)	157	1.76	6.4	6.3	16.3	10
14293	Little Rock	do	Porphyritic syenite	(2)	163	.20	3.7	10.8	18.5	12
		CALIFORNIA.								
14496	Kennett	Shasta	Copper slag	(2)	221	1.09	4.9	8.2	17.7	9
		COLORADO.								
13892	Near Boulder	Boulder	Feldspar basalt	(2)	174	.56	2.9	13.8	18.8	18
14998	Denver	Denver	Lead slag	(2)	217	.49	7.8	5.1	(2)	(2)
15016	Pueblo	Pueblo	Lead smelter slag	(2)	213	.53	5.5	7.3	(2)	(2)
15017	do	do	do	(2)	223	.44	6.0	6.7	(2)	(2)
15018	do	do	do	(2)	220	.34	5.6	7.1	(2)	(2)
		CONNECTICUT.								
14965	(1)	Hartford	Altered diabase	(2)	184	.25	3.0	13.3	18.0	20
14970	(1)	do	do	(2)	185	.24	2.7	14.8	17.3	22
13865	Oneco	Windham	Granite	(2)	(2)	(2)	4.5	8.9	18.0	8
		DELAWARE.								
15401	(1)	Kent	Pyroxene quartzite	(2)	177	.18	3.3	12.1	18.7	13
13893	Elsmere	New Castle	Plagioclase gneiss	(2)	168	.20	3.6	11.1	18.7	9
14025	Stoney Battery	do	Hornblende schist	(2)	191	.25	3.6	11.1	17.7	8
14114	Wilmington	do	Hornblende gneiss	(2)	194	.16	3.1	12.9	17.2	11
15367	do	do	Pyroxene quartzite	(2)	175	.69	3.3	12.1	18.7	12
		GEORGIA.								
13914	Atlanta	Fulton	Granite	(2)	(2)	(2)	4.4	9.1	18.0	9
15378	Near Talbot	Talbotton	Diabase	(2)	187	.32	1.7	23.5	18.7	27
		ILLINOIS.								
14426	South Chicago	Cook	Slag	(2)	141	3.48	9.1	4.4	14.3	6
14949	(1)	Madison	Fossiliferous limestone	(2)	166	1.19	6.0	6.7	18.3	10
		INDIANA.								
15352	Henryville	Clark	Dolomitic limestone	(2)	172	1.06	3.5	11.4	17.0	13
14871	Eaton	Delaware	Dolomite	(2)	169	1.43	5.8	6.9	15.7	6
15374	Floyds Knobs	Floyd	Limestone	(2)	164	2.43	4.7	8.5	13.3	6
15375	do	do	Feldspathic sandstone	(2)	132	9.64	11.8	3.4	3.7	4
15376	do	do	do	(2)	134	9.75	10.9	3.7	0.0	3
14730	Monon	White	Dolomite	(2)	170	.41	5.6	7.1	15.7	7
		IOWA.								
13913	Brandon	Blackhawk	Limestone	(2)	161	.36	4.7	8.5	15.0	4
13903	Stone City	Jones	Dolomite	(2)	132	11.81	14.5	2.7	0.0	4
		KANSAS.								
14882	2½ miles west Woodruff.	Phillips	Sandstone	(2)	144	1.77	5.7	7.0	18.7	7
14711	(1)	Riley	Dolomite	(2)	174	2.20	4.0	10.0	15.8	10

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Results of physical tests of road-building rocks from the United States and Canada, Jan. 1, 1919, to Jan. 1, 1920—Continued.

Serial No.	Town or city.	State and county.	Name of material.	Crushing strength, pounds per square inch.	Weight per cubic foot, pounds.	Absorption, pounds per cubic foot.	Per cent of wear.	French coefficient of wear.	Hardness.	Toughness.
		MAINE.								
13862	(1)	Hancock	Granite	(2)	(2)	(2)	3.7	10.8	18.7	10
13866	(1)	Knox	do	(2)	(2)	(2)	3.4	11.8	18.0	10
13868	(1)	do	do	(2)	(2)	(2)	3.4	11.8	18.7	10
13869	(1)	do	do	(2)	(2)	(2)	3.3	12.1	18.7	10
		MARYLAND.								
14167	Baltimore	Baltimore	Copper blast-furnace slag	(2)	203	.97	5.5	7.3	17.3	13
14179	do	do	do	(2)	205	.95	5.2	7.7	15.3	11
14193	do	do	do	(2)	199	.72	3.1	12.9	(2)	(2)
14646	Towson	do	Marble	(2)	175	.38	9.9	4.1	11.0	4
15387	(1)	do	do	(2)	172	.30	5.4	7.4	(2)	(2)
15161	Sylmar-Rising Sun	Cecil	Hypersthene granite	(2)	183	2.02	(2)	(2)	18.0	10
14548	Bel Air	Harford	Amphibolite	(2)	190	.17	2.8	14.3	18.7	21
14424	Weaverton	Washington	Quartzite	(2)	167	.31	3.1	12.9	(2)	(2)
		MASSACHUSETTS.								
15178	Seekonk	Bristol	Feldspathic sandstone	(2)	165	1.21	4.3	9.3	18.7	14
15179	do	do	Siliceous slate	(2)	164	1.84	3.9	10.3	(2)	(2)
14987	(1)	Essex	Trachytic rhyolite	(2)	166	.10	3.1	12.9	19.3	15
15174	Rockport	do	Granite	34,200	(2)	(2)	(2)	(2)	(2)	11
15175	do	do	do	31,225	(2)	(2)	(2)	(2)	(2)	10
15176	do	do	do	24,275	(2)	(2)	(2)	(2)	(2)	8
15177	do	do	do	32,125	(2)	(2)	(2)	(2)	(2)	11
15156	Cummington	Hampshire	Mica-schist	(2)	166	1.54	6.2	6.5	17.0	9
15157	do	do	Chlorite mica-schist	(2)	165	1.35	7.7	5.2	17.3	6
15158	do	do	Mica-schist	(2)	131	.55	4.3	9.3	17.7	7
14890	Chelmsford	Middlesex	Muscovite granite	(2)	163	.88	3.9	10.3	18.7	9
13885	Westford	do	Granite	(2)	(2)	(2)	4.6	8.7	18.0	9
13894	do	do	do	(2)	(2)	(2)	3.1	12.9	19.3	9
14652	Quincy	Norfolk	Altered granite	(2)	163	.91	5.3	7.6	18.7	(2)
14897	Randolph	do	Feldspathic quartzite	(2)	163	.91	3.3	12.1	18.7	10
15292	Hingham	Plymouth	Aplitic granite	(2)	130	.42	2.7	14.8	18.3	18
15291	(1)	Suffolk	Altered rhyolite	(2)	131	.59	2.6	15.4	19.0	12
14878	West Roxbury	do	Altered diabase	(2)	192	.19	1.8	22.2	18.7	24
14917	do	do	Granite	(2)	167	.25	4.1	9.8	18.7	10
15164	(1)	do	Altered diabase	(2)	192	.63	2.2	18.2	18.0	18
		MICHIGAN.								
14623	Rogers	Presque Isle	Limestone	(2)	162	1.30	9.5	4.2	13.3	5
14689	Inwood	Schoolcraft	Dolomitic marble	(2)	177	.46	4.8	8.3	16.0	8
		MINNESOTA.								
14495	(1)	Rock	Quartzite	(2)	168	.38	2.4	16.7	(2)	(2)
15214	(1)	St. Louis	Epidosite	(2)	218	.48	2.6	15.4	18.7	20
		MISSISSIPPI.								
14283	Iuka	Tishomingo	Weathered chert	(2)	127	7.89	12.2	3.3	(2)	(2)
		MISSOURI.								
14731	Kansas City	Jackson	Limestone	(2)	164	.74	5.5	7.3	13.3	5
14448	North of Webb City	Jasper	Chert	(2)	155	2.96	4.4	9.1	19.7	(2)
		MONTANA.								
14363	Logan	Gallatin	Limestone	(2)	169	.36	3.4	11.8	(2)	(2)
14466	Trident	do	do	(2)	166	.72	6.8	5.9	(2)	(2)
14467	do	do	Siliceous limestone	(2)	164	1.43	3.4	11.8	17.0	14
14360	Livingston	Park	Basalt	(2)	178	1.95	4.6	8.7	16.7	10
13897	(1)	Yellowstone	Sandstone	(2)	135	9.27	26.3	1.5	13.5	7
		NEBRASKA.								
14581	(1)	Cass	Cherty limestone	(2)	163	1.27	4.8	8.3	15.0	7
14582	(1)	do	Siliceous limestone	(2)	162	2.65	6.7	6.0	13.3	5
		NEW HAMPSHIRE.								
13864	(1)	Cheshire	Granite	(2)	(2)	(2)	4.0	10.0	16.7	8
13860	(1)	Hillsboro	do	(2)	(2)	(2)	5.1	7.8	18.0	7
13861	(1)	do	do	(2)	(2)	(2)	4.3	9.3	17.3	8
13883	Brookline	do	do	(2)	(2)	(2)	3.3	12.1	18.0	8
13863	(1)	Merrimack	do	(2)	(2)	(2)	3.4	11.8	18.7	9
13867	(1)	do	do	(2)	(2)	(2)	3.4	11.8	18.7	10
14892	Concord	do	do	(2)	164	.75	4.6	8.7	17.7	10
		NEW JERSEY.								
14638	(1)	Essex	Basalt	(2)	183	.15	2.4	16.4	17.6	12
14869	(1)	Hunterdon	Dolomite	(2)	177	.39	3.0	13.3	15.3	8
14379	Chrome	Middlesex	Copper slag	(2)	221	.45	4.1	9.8	16.7	25
14644	Maurer	do	do	(2)	218	1.35	2.9	13.8	16.7	15
14973	Chimney Rock	Somerset	Basalt	(2)	180	.59	2.1	19.0	18.0	18
14641	Bound Brook	do	Diabase	(2)	186	.15	1.6	25.0	19.3	27
14982	(1)	do	Altered basalt	(2)	183	.29	2.2	18.2	18.7	21
14983	(1)	do	do	(2)	186	.21	1.8	22.2	18.0	31
		NEW YORK.								
13890	Alexandria Bay	Jefferson	Granite	(2)	(2)	(2)	2.9	13.8	18.7	11
14462	Oaks Corners	Ontario	Argillaceous limestone	(2)	166	1.63	3.8	10.5	14.3	8

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		NORTH CAROLINA.								
13901	Craggy	Buncombe	Granite	(2)	163	0.49	2.8	14.3	18.5	12
14753	(1)	Durham	Gneissoid granite	(2)	165	.43	4.1	9.8	18.0	7
14403	Belmont	Gaston	Biotite granite	(2)	171	.39	3.5	11.4	17.8	8
14514	(1)	Mecklenberg	Weathered granite	(2)	163	.37	4.5	8.9	18.0	8
14515	(1)	do	Quartzite	(2)	166	.54	2.3	17.4	(2)	(2)
14516	(1)	do	Uralite diabase	(2)	182	.80	2.9	13.8	18.7	14
15285	(1)	do	Altered biotite granite	(2)	134	.65	3.7	10.8	18.3	26
14633	(1)	do	Epidote quartzite	(2)	174	.85	3.0	13.3	18.7	29
13972	Salisbury	Rowan	Granite	(2)	(2)	(2)	3.3	12.1	19.0	10
15009	Granite Quarry	do	do	(2)	163	.57	3.5	11.4	18.0	15
14891	Mount Airy	Surry	do	(2)	164	.71	4.6	8.7	18.0	6
14244	Henderson	Vance	Gneissoid granite	(2)	170	.45	2.8	14.3	18.0	6
15078	Greystone	do	do	35,140	163	.72	3.6	11.1	18.0	7
15079	do	do	do	31,050	162	.79	3.4	11.8	18.0	7
14174	Wendell	Wake	Biotite granite	(2)	(2)	(2)	(2)	(2)	18.0	5
14175	Raleigh	do	do	(2)	163	.47	3.2	12.5	(2)	(2)
15012	Near Raleigh	do	Olivine diabase	(2)	186	.38	1.7	23.5	18.0	19
		OHIO.								
14016	Delphos	Allen	Argillaceous dolomite	(2)	169	.20	4.8	8.3	16.2	6
14018	do	do	Dolomite	(2)	174	1.04	5.1	7.8	15.3	9
14019	do	do	do	(2)	171	.89	4.4	9.1	14.7	9
14772	do	do	Argillaceous dolomite	(2)	170	.70	4.8	8.3	15.3	13
15216	Lima	do	do	(2)	165	1.86	3.7	10.8	14.7	9
14524	Richland	Clinton	do	(2)	157	3.48	9.4	4.3	13.3	5
15096	Latonia	Columbiana	Blast-furnace slag	(2)	111	8.42	16.2	2.5	(2)	(2)
15215	Delaware	Delaware	Argillaceous limestone	(2)	163	.93	5.3	7.6	15.8	8
14525	Homer	Highland	Argillaceous dolomite	(2)	169	1.35	7.4	5.4	12.7	5
14833	Lorain	Lorain	Blast furnace slag	(2)	123	5.89	16.8	2.4	(2)	(2)
15217	Circleville	Pickaway	Dolomitic marble	(2)	164	2.82	4.4	9.1	14.7	9
13888	Woodville	Sandusky	Dolomite	(2)	159	3.85	5.8	6.9	16.0	7
14771	Middlepoint	Van Wert	do	(2)	166	2.07	5.0	7.9	15.7	8
15047	North Baltimore	Wood	Argillaceous dolomite	(2)	168	2.57	4.6	8.7	(2)	(2)
		OKLAHOMA.								
14997	Near Armstrong	Bryan	Fossiliferous limestone	(2)	164	1.49	6.3	6.4	13.3	6
15118	Near Caddo	do	Limestone	(2)	153	5.07	6.4	6.3	0.0	5
14914	Tulsa	Tulsa	Argillaceous limestone	(2)	165	1.16	7.1	5.6	14.7	6
		PENNSYLVANIA.								
14382	Carnegie	Allegheny	Copper slag	(2)	238	.38	4.3	9.3	17.3	14
14468	Birdsboro	Berks	Diabase	(2)	188	.35	(2)	(2)	18.7	10
14642	Douglass Township	do	Altered slate	(2)	170	.32	1.9	21.1	18.7	28
14150	Johnstown	Cambria	Open-hearth slag	(2)	186	2.02	11.0	3.6	(2)	(2)
14151	do	do	Slag	(2)	128	6.88	18.9	2.1	(2)	(2)
14111	Palmerton	Carbon	Spiegel slag	(2)	122	7.52	13.1	3.1	(2)	(2)
14294	Howellville	Chester	Marble	(2)	173	.36	4.3	9.3	(2)	(2)
14943	Devault	do	Dolomitic marble	(2)	176	.70	7.7	5.2	14.0	5
13993	Point Marion	Fayette	Feldspathic sandstone	(2)	151	3.53	10.3	3.9	11.0	6
15199	Fayetteville	Franklin	Quartzite	(2)	158	.85	4.9	8.2	19.0	11
14999	Emaus	Lehigh	Altered diorite	(2)	175	.77	5.8	6.9	(2)	7
15351	(1)	do	Diorite	(2)	184	.91	5.0	8.0	18.0	10
13939	Ivy Rock	Montgomery	Dolomitic marble	(2)	177	.26	4.9	8.2	15.3	7
14691	Gwynedd Valley	do	Siliceous limestone	(2)	169	.35	2.3	17.4	17.7	19
15264	Glendon	Northampton	Slag	(2)	174	1.98	6.1	6.6	15.7	8
13907	Holmesburg	Philadelphia	Granite	(2)	(2)	(2)	4.9	8.2	18.7	8
14785	Matamoras	Pike	Feldspathic sandstone	(2)	165	1.04	5.0	8.0	15.0	10
		SOUTH CAROLINA.								
14765	Near Rion	Fairfield	Biotite granite	20,100	164	.69	3.5	11.4	18.0	12
14457	Cayce	Lexington	do	33,090	163	.51	2.5	16.0	18.3	13
14298	4 miles east of McCormick.	McCormick	Altered andesite	(2)	171	2.82	10.6	3.8	16.7	8
14301	Near McCormick	do	Quartz	(2)	163	.34	9.8	4.1	(2)	(2)
15153	Lockhart	Union	Diorite	(2)	189	.64	2.4	16.7	19.0	10
		TENNESSEE.								
14464	Johnson City	Washington	Siliceous limestone	(2)	175	.29	2.5	16.0	17.3	16
14840	Brayesville	do	Limestone	(2)	170	.84	6.6	6.1	15.3	4
14841	Washington College	do	do	(2)	169	.49	5.7	7.0	15.3	5
		TEXAS.								
13980	El Paso	El Paso	Lead slag	(2)	222	1.60	7.1	5.6	(2)	(2)
15004	(1)	do	Smelter slag	(2)	224	.80	4.8	8.3	(2)	(2)
15005	(1)	do	Lead smelter slag	(2)	212	.65	9.8	4.1	(2)	(2)
		UTAH.								
15261	Poison Spring Bench	Price	Argillaceous limestone	(2)	139	4.66	8.4	4.8	10.7	5
14250	Price	Carbon	Limestone	(2)	168	.47	4.9	8.2	16.7	6
14251	do	do	Argillaceous limestone	(2)	166	.91	4.5	8.9	15.3	7
14257	do	do	do	(2)	156	3.28	5.8	6.9	15.3	7
14258	do	do	Calcareous sandstone	(2)	161	2.15	6.3	6.4	14.7	8
14867	(1)	Carbon and Emery	Argillaceous limestone	(2)	144	5.93	7.3	5.5	12.0	3
14868	(1)	do	Limestone	(2)	166	.87	4.7	8.5	16.0	7
14252	Castledale	Emery	Limestone conglomerate	(2)	154	3.95	17.3	2.3	(2)	(2)
14253	do	do	Argillaceous limestone	(2)	168	.48	4.7	8.5	16.0	6
14254	do	do	Calcareous sandstone	(2)	161	2.08	3.3	12.1	15.3	19
14255	do	do	do	(2)	166	1.79	7.6	5.3	14.7	7
14249	Emery	do	Limestone	(2)	162	2.16	7.1	5.6	16.0	12
13999	Garfield	Salt Lake	Copper slag	(2)	210	1.03	4.9	8.2	(2)	(2)
15107	do	do	do	(2)	202	.27	5.0	8.0	(2)	(2)
15109	do	do	do	(2)	208	1.37	6.6	6.0	18.0	18
14643	Midvale	do	Lead slag	(2)	221	.97	4.7	8.5	14.7	7

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		VIRGINIA.								
14131	Meachums River	Albemarle	Biotite gneiss	(2)	177	0.74	5.4	7.4	17.0	6
14870	Lynchburg	Amherst	Amphibolite	(2)	188	.81	5.3	7.6	16.7	7
14881	Lone Fountain	Augusta	Limestone	(2)	169	.22	5.8	6.9	16.0	4
15187	(1)	do	do	(2)	169	.51	6.3	6.4	15.7	4
15188	(1)	do	do	(2)	168	.52	5.0	8.0	15.7	9
13906	Blue Ridge	Bedford	Siliceous dolomite	(2)	174	.17	4.8	8.3	16.7	10
13990	West of Lynchburg	do	Gabbro	(2)	175	.31	4.9	8.2	18.7	7
14224	Major	do	Altered andesite	(2)	188	.43	2.7	14.8	17.3	9
14449	(1)	Botetourt	Limestone	(2)	195	.17	6.2	6.5	15.0	5
15111	Near Buchanan	do	Siliceous dolomite	(2)	176	.65	3.3	12.1	16.3	12
14651	Near Bocock	Campbell	Sericite gneiss	(2)	165	.77	6.0	6.7	18.0	7
15011	Herndon	Fairfax	Rhyolite breccia	(2)	167	2.32	5.9	6.8	(2)	(2)
14460	(1)	Fauquier	Epidosite	(2)	194	1.32	6.0	6.7	18.3	(2)
15382	Marshall	do	Altered granite	(2)	162	2.16	6.6	6.1	18.0	8
14583	(1)	Frederick	Limestone	(2)	171	.10	8.4	4.8	15.3	3
14879	Winchester	do	Dolomite	(2)	173	.28	3.5	11.4	16.7	14
14880	do	do	Calcareous slate	(2)	158	3.16	8.9	4.5	0.0	5
14969	do	do	Dolomite	(2)	176	.21	3.0	13.3	17.3	15
14463	Pembroke	Giles	Siliceous dolomite	(2)	177	.30	3.2	12.5	16.3	9
14493	Ripplemead	do	do	(2)	175	.52	2.7	14.8	17.3	13
13917	Stickleyville	Lee	Limestone	(2)	168	.34	6.1	6.5	16.3	4
13918	do	do	Argillaceous limestone	(2)	169	.30	6.0	6.6	15.7	5
14584	(1)	do	Siliceous limestone	(2)	168	.30	5.7	7.0	14.7	7
14197	Point of Rocks	Loudoun	Sericite gneiss	(2)	168	.36	5.7	7.0	19.3	12
14198	do	do	Limestone conglomerate	(2)	175	.33	4.5	8.9	(2)	(2)
14284	Between Blacksburg and Newport.	Montgomery	Feldspathic sandstone	(2)	161	1.73	(2)	(2)	16.7	8
15152	Arrington	Nelson	Amphibolite	(2)	185	1.42	3.5	11.4	18.3	14
14384	(1)	Pittsylvania	Biotite gneiss	(2)	170	.41	4.5	8.9	18.0	6
15366	Occoquan	Prince William	Altered granite	(2)	163	1.06	4.7	8.5	19.3	8
14461	(1)	Rappahannock	do	(2)	163	.70	3.8	10.5	18.3	12
14988	(1)	Roanoke	Dolomite	(2)	176	.64	5.1	7.8	16.0	7
14017	Timber Ridge	Rockbridge	Siliceous dolomite	(2)	182	.31	2.8	14.3	17.9	12
15112	do	do	Siliceous limestone	(2)	177	.18	3.8	10.5	18.3	21
15113	do	do	do	(2)	175	.13	3.0	13.3	17.7	14
		WASHINGTON.								
15398	(1)	Whatcom	Altered trachyte	(2)	(2)	(2)	(2)	(2)	(2)	15
		WEST VIRGINIA.								
13886	Belington	Barbour	Sandstone	(2)	147	2.60	7.7	5.2	17.3	7
14263	Martinsburg	Berkeley	Limestone	(2)	169	.15	(2)	(2)	14.7	6
14264	do	do	Diabase	(2)	187	.24	(2)	(2)	18.7	20
14265	do	do	Limestone	(2)	170	.08	9.0	4.4	14.7	3
14266	do	do	do	(2)	169	.09	7.3	5.5	14.0	3
14358	Kingston	Fayette	Feldspathic sandstone	(2)	156	3.06	9.3	4.3	14.3	9
13908	Hamlin	Lincoln	Sandstone	(2)	153	4.98	8.7	4.6	12.0	5
13992	do	do	do	(2)	156	3.90	8.6	4.6	3.3	3
14625	Logan	Logan	Calcareous sandstone	(2)	169	.86	7.5	5.3	13.3	7
14733	Berkeley Springs	Morgan	Quartzite	(2)	164	.41	2.6	15.4	19.3	22
14710	Wheeling	Ohio	Blast furnace slag	(2)	130	6.96	7.0	5.7	(2)	(2)
14320	Hurricane	Putnam	Feldspathic sandstone	(2)	153	4.47	11.7	3.4	2.7	4
14133	Beckley	Raleigh	do	(2)	159	2.62	3.8	10.5	15.3	7
14134	do	do	Sandstone	(2)	153	3.03	4.5	8.9	17.2	6
14176	Sylvia	do	do	(2)	160	1.69	6.0	6.6	14.8	6
14245	Spencer	Roane	Calcareous sandstone	(2)	165	1.32	4.7	8.5	15.0	9
13887	Middlebourne	Tyler	Sandstone	(2)	154	4.15	7.8	5.1	9.3	5
14281	East of Littleton	Wetzel	Feldspathic sandstone	(2)	144	6.22	19.1	2.1	9.0	3
14282	do	do	do	(2)	151	4.64	10.6	3.8	6.7	4
		WISCONSIN.								
14132	Brillion	Calumet	Dolomite	(2)	173	.98	4.6	8.7	12.5	4
14759	Madison	Dane	do	(2)	(2)	(2)	(2)	(2)	16.0	(2)
14676	Montello	Marquette	Granite	(2)	164	.25	2.4	16.7	18.7	16
		CANADA.								
13920	Burnt River	Ontario Province	Siliceous limestone	(2)	174	.68	3.1	12.9	15.7	11

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[1] Exact locality not known.

[2] Test not made.

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BUREAU OF PUBLIC ROADS

Public Roads

VOL. 2, NO. 24 WASHINGTON, D. C. APRIL, 1920

3-B ARMY TRUCK—19,000 TRUCKS TURNED OVER TO STATES FOR ROAD WORK

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1920

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U. S. DEPARTMENT OF AGRICULTURE

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PUBLIC ROADS

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HOUSING AND EQUIPMENT OF ARMY TRUCKS BY THE STATES.

BIRD'S-EYE VIEW OF THE STORAGE SHEDS AND GARAGE ERECTED BY VERMONT.

THE distribution of surplus war materials among the several States for use in Federal-aid road construction authorized last year by Congress marked a distinct departure in governmental policy. The action of the Government could not have been long anticipated by the State officials, and it would have surprised no one, therefore, if the early deliveries, particularly the deliveries of motor trucks, had found many of the State highway departments inadequately prepared to receive and care for them.

Many of the trucks had already been exposed to the weather for long periods when they were shipped to the States, and had suffered more or less serious deterioration as a result. Naturally the first concern of the State officials was to provide sufficient shelter to prevent further deterioration. This done, and the opportunity for detailed inspection of their unexpected acquisitions presenting itself, the State departments were not long in discovering that few of the trucks were suitable for immediate use in highway work. Many of them were found to be deficient in necessary mechanical parts. Some could not be operated at all in the condition in which they were received, and required thorough overhauling before they could be moved under their own power. But even aside from these defects, the majority of them were equipped with bodies entirely unsuited to the work of highway construction.

The problem which many of the States faced, therefore, was the immediate organization and equipment of a plant for the storage, repair, and alteration of a much larger stock of mechanical equipment than their previous plans had ever contemplated. The problem was a difficult one. It was so difficult and so unusual that it is interesting to learn how the several States have solved it. Each State department, with the means at its disposal, and practically without reference to what was being done along similar lines in other States, has already worked out its own solution. The plans of each have now developed to the point where it is possible to describe some of the more ingenious methods which have been employed and the general lines of procedure in all of the States. Perhaps such a description, involving somewhat of an exchange of experiences, may be beneficial to all. Surely some department will find in the experience of another something of value which it can apply to advantage.

With this in mind PUBLIC ROADS addressed inquiries to each of the State highway departments in regard to the provisions made for housing and repair; the nature of the body alterations which were being made, such as the installation of dumping bodies and hoists; and the cost of such alterations or equipments.

Thirty-eight of the 48 States responded, giving, with more or less detail, statements of their progress to date. A general summary of these replies and full descriptions of the more striking features are reported below.

SOME ALLOT TRUCKS TO COUNTIES.

Twelve of the 38 States report that they have distributed the majority of their allotment of trucks among their counties, retaining only a few for the use of the State highway department. These States are Alabama, Arkansas, Georgia, Idaho, Kentucky, Mississippi, Missouri, South Dakota, Texas, Washington, West Virginia, and Wisconsin. The State of Ohio, also, has allotted a considerable number of its trucks to the counties for use on Federal-aid work. In five of these States—Georgia, Idaho, Mississippi, Texas, and West Virginia—the trucks are overhauled and put into good running condition before they are allotted to the counties. The others transfer them to the counties as they are received; but at least one of this latter group—Missouri—has had some trouble in disposing of some of the less serviceable trucks. As the State highway superintendent says, "each of the six division engineers has five or six on his hands that no county is willing to pay the freight and loading charges on." These will probably be repaired by the State.

The condition upon which the trucks are distributed and the degree of control retained by the State appear to vary. Arkansas prescribes that they shall be used by the counties for maintenance work except in the counties in which construction has not advanced sufficiently to make their utilization for maintenance profitable. Such counties are permitted to employ the trucks for construction purposes.

The highway department of Georgia retains full title to the trucks it distributes and requires the counties to enter into a contract limiting the use of them to such road work as the State department may indicate. The same instrument binds the county to furnish cover for the trucks when they are not in use and to keep them in repair after they are received. In addition to all these conditions the county is required to deposit with the State 10 per cent of the value of the equipment, which it is estimated will cover freight, handling charges, insurance, and inspection charges during the life of the truck.

Idaho and Texas condition their distribution upon the agreement of the counties to make all necessary repairs and to provide covered storage for trucks when not in use. Mississippi exacts the promise that adequate provision will be made for housing.

All the States of this group require the counties to house and repair the equipment they receive, but in the States other than those mentioned the means for enforcing reasonable precautions for the protection of the trucks seem to be lacking, unless the desire of the counties for future allotments of equipment may be employed for that purpose.

Investigation of the conditions of storage in the West Virginia counties by a division engineer of the State road commission shows that in many cases the counties have provided repair shops of their own; in others they have contracted with private garages for storage and upkeep. In most cases, it is reported, former Army men are looking after the trucks. The instructions of the Motor Transport Corps in regard to housing have been issued to the county engineers and the division engineers say they are being followed.

HOW THE PLAN WORKS IN MISSOURI.

Reports from 44 counties in Missouri, to which have been allotted 131 trucks, reveal the fact that all have been adequately housed with the exception of one 2-ton Nash. The character of the housing provided for the others varies from what is described as a good shed to newly constructed brick, concrete, or galvanized-iron garages, many of them with concrete floors and well-equipped repair shops attached. On page 7 are shown exterior and interior views of the garage constructed by Jasper special road district in Jasper County. The wooden structure has a corrugated galvanized-iron roof and a 6-inch concrete floor of sufficient area to accommodate sixteen 3-ton trucks. There is a door at each end of the garage, which does away with the necessity of backing either in or out of the building.

Many of the trucks have been equipped by the counties with special bodies suitable for their work. These are of all types, from simple wooden dump beds, installed at a cost of only $25 per truck, to modern steel dump bodies with hydraulic hoists, which cost $784. A few of the trucks have been equipped with water tanks, at a cost of $180, for use in macadam road construction. The type of dump body and hand hoist installed in the Hollister-Kirbyville special road district in Taney County is an inexpensive one, the cost being but $275. The type is shown in the illustration on page 13. The garage in which the truck is housed is shown in the background.

A number of the counties are using the trucks just as they are received; and one county, which plans to install special bodies, has asked the State department to give it assurance that the equipment will be permitted to remain in the county before it undertakes the expense.

Nearly all counties report that the trucks have been placed in care of expert mechanics, and all but a few report that the cost of repairs has so far been very light. General satisfaction with the performance of the equipment is expressed in all reports, one county going so far as to add that its allotment of two 2-ton Nash trucks has saved it $1,000 during 1919.

ABOVE, PENNSYLVANIA'S GARAGES IN COURSE OF CONSTRUCTION. BELOW, TILE GARAGES BUILT BY IOWA.

RENTS TRUCKS TO CONTRACTORS.

Trucks which are assigned to counties by the Wisconsin highway commission must be housed and kept in repair by them. Many of the counties already had garages, and those which were not so fortunate have arranged to house the equipment in county fair buildings or in rented space in private garages. In the work of repairing the trucks the counties have the assistance of the mechanical department of the State commission, which keeps a large stock of parts on hand for such work. Parts called for by the counties which are not on hand are purchased direct from the manufacturer and shipped from the factory to the county, but in the future the commission proposes to furnish all parts itself.

About 120 trucks in all have been assigned to the counties. The balance of the State's allotment is maintained by the mechanical department for rental to contractors and counties for use on Federal-aid projects. These trucks are rented on condition that the parties who rent them will make all necessary running and service repairs, but the mechanical department renders some assistance by furnishing parts and mechanics to make repairs when called upon. At the end of the season all rented trucks are taken to one of the State's repair shops for thorough overhauling. The main repair shop is at West Allis,

LIGHT AVIATION TRUCK EQUIPPED TO TRANSPORT LABORERS.

Wis., and has been fitted up with machinery, hoists, a blacksmith shop, and other equipment necessary for general overhauling work. The other shops are operated in connection with local garages in other parts of the State.

During the coming season about 50 trucks will be rented without bodies. On these chassis the contractors will mount platform beds, but practically all others will be equipped with hoist and dump bodies. Three types of hoists have been used so far—one a hand hoist and the others hydraulic hoists. Views of these types are shown on pages 9, 13, and 16.

The actual cost of installing the hydraulic hoists and 2-cubic-yard dump bodies is $525, including the war tax. The cost of the same hoists and 3-cubic-yard bodies is $575. So far these bodies have been mounted only on 2 and 3 ton trucks. On page 6 is shown a light aviation truck equipped with a canvas top on bow frames, and longitudinal seats accommodating 15 men, which is used for the transportation of field parties and laborers.

IDAHO INSTALLED HOPPER BODIES.

Idaho has developed a type of hopper body, with a hand-dumping device, which it has installed on the Nash quads which are equipped with steel ammunition bodies, at a cost of only $85 per truck. An interior view of one of these bodies, disclosing the dumping device, is shown on page 21, and on page 8 are given detailed plans for the construction of this body.

Before the Mississippi trucks are distributed to the counties they are put into good running condition and are equipped with standard steel dump bodies with hand hoists. All trucks are painted uniformly, with the name of the State department and a serial number lettered on the sides of the body. All this work costs approximately $500 per truck, but the Mississippi officials are confident that the money is well spent. On page 9 is shown a truck equipped with one of the standard bodies in the elevated position.

COUNTY ALLOTMENT UNSATISFACTORY.

After a trial of the plan of alloting the trucks to its counties, the department of State lands, highways, and improvements in Arkansas finds that it does not work satisfactorily. Officials of the State department are convinced that a maximum of usefulness can not be secured from the trucks by this method. Accordingly, they plan in the future to lease all equipment received from the War Department to contractors and commissioners for use on specific road projects. In this way they hope to place the trucks where they will be of the most use and of the greatest benefit to the State as a whole. In reaching this decision to rent the trucks they are following the same course which has been adopted in Wisconsin, Iowa, Illinois, Montana, and perhaps other States.

The States previously referred to allot the majority of their trucks to counties. The rest from which reports have been received employ practically all of their equipment directly under the control of the State highway department, or by lease to contractors, on State road work. The States of this group are: Colorado, Connecticut, Delaware, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, and Utah.

HOUSING OF TRUCKS BY STATES.

The problem of housing the trucks retained by the States is naturally a much more difficult one than that with which the counties have had to deal because of the greater number of trucks which must be provided for, but, except in two or three of the States of this group, all equipment received from the Government had been adequately housed by January, 1920. The provision which has been made in the several States varies considerably in character. Seven of them, temporarily at least, are employing buildings on State fair grounds. One State has taken over an abandoned street-car barn; one an abandoned motor-truck plant; one State uses an old stable which has been converted into a garage and repair shop; two States have rented buildings suitable for the purpose; one State has arranged for a large frame building; two are storing in private garages; and at least six have well-designed buildings completed or under construction for the special purpose of housing their trucks.

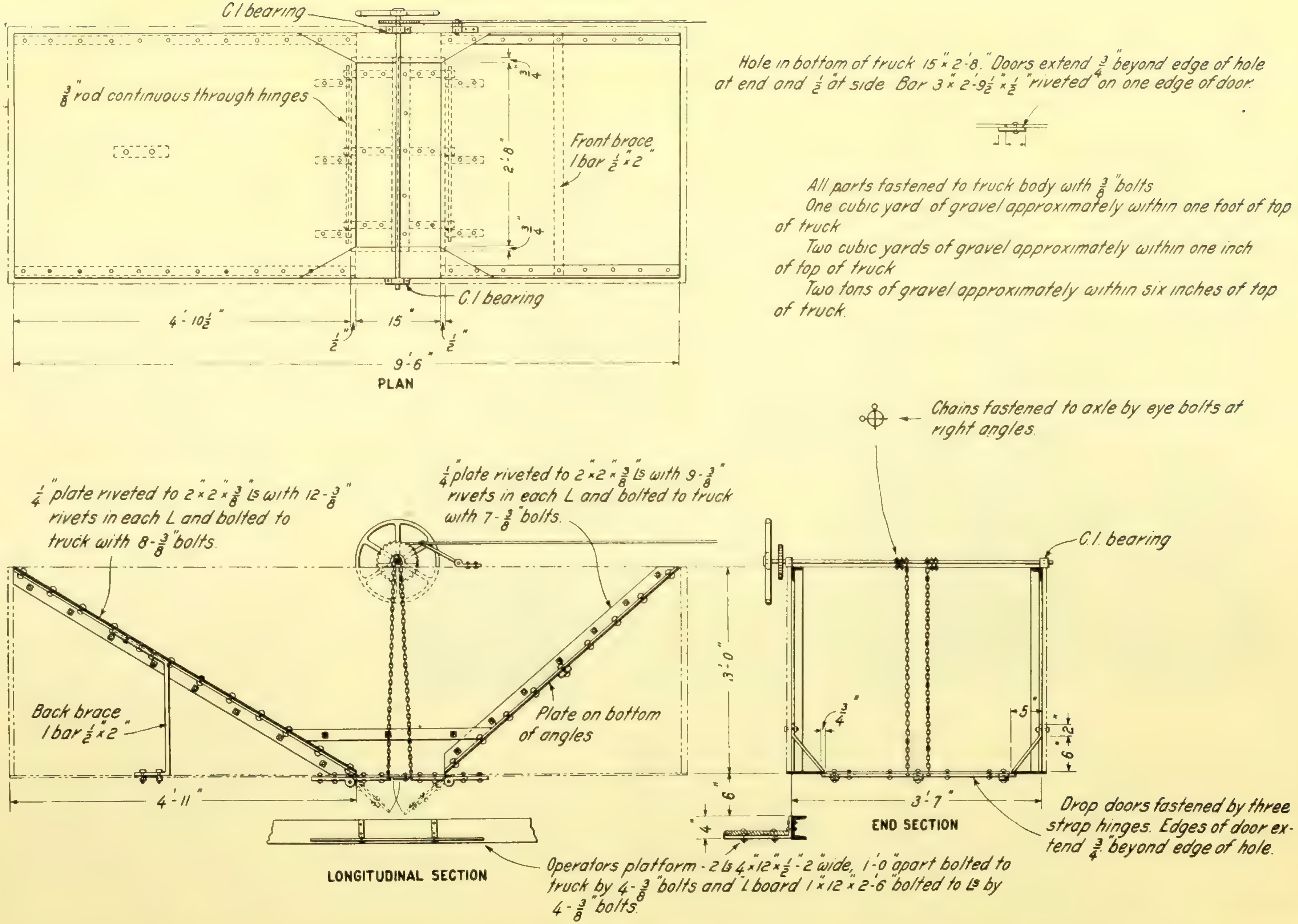
TILE GARAGES ERECTED IN IOWA.

Iowa has practically completed the construction of four buildings, each 52 feet 6 inches wide by 142 feet 6 inches long, for the storage of its allotment of trucks. The walls, 12 feet high from floor to eaves, are of hollow tile, stiffened by brick columns at frequent intervals. In one end of one of the buildings provision has been made for a repair shop, 50 feet wide by 60 feet in length; and connecting with this shop by a large door there is a "parts" storage room 27 by 50 feet. The repair shop and parts room have concrete floors. All other parts of the building have cinder floors. The buildings to be used for the storage of trucks are provided with doors so arranged that any truck can be taken out by moving not more than one other truck. This is an exceedingly important feature of the design of such buildings and one which it will be well that other States bear in mind in connection with the design of their housing facilities. In addition to the four buildings described, Iowa has arranged for the use of the State fair buildings at Des Moines, in which a large number of trucks are stored. However, it is hoped that four additional buildings of the type described will be built during the coming season, thus enabling the highway commission to store all of its equipment at Ames. An exterior view of the new buildings is shown on page 5.

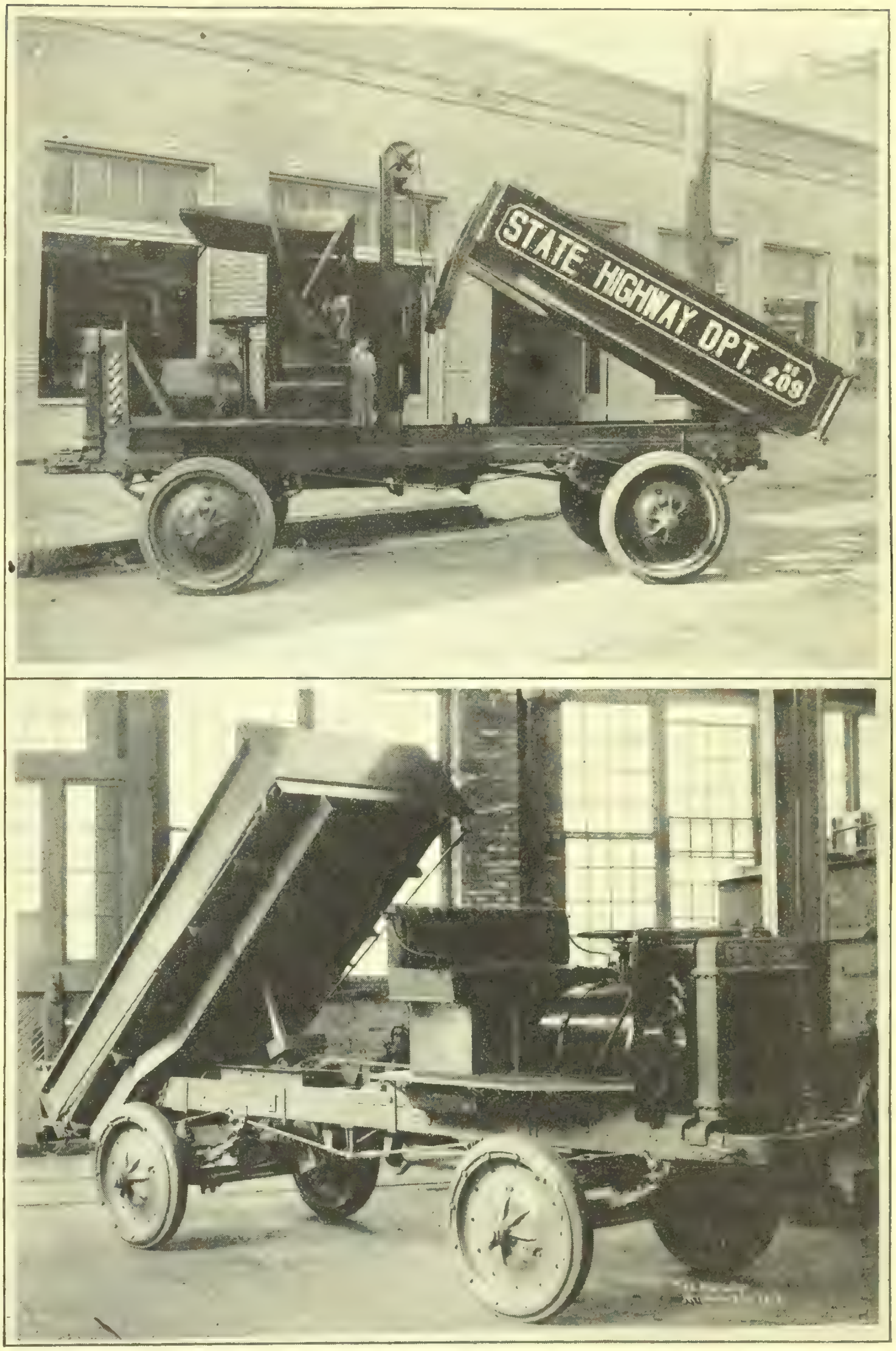
INTERIOR AND EXTERIOR VIEWS OF GARAGE IN WHICH ARE HOUSED THE TRUCKS ALLOTTED TO JASPER SPECIAL ROAD DISTRICT, JASPER COUNTY, MISSOURI.

THREE STATES STORE IN SHEDS.

Utah's provision for the trucks is radically different from that of Iowa, but apparently none the less effective. A large shop building of concrete, with windows occupying practically the entire wall area, has been erected to house its very complete equipment of machine tools and forging apparatus. The machine shop section contains a traveling crane, drill presses, lathes, planers, and practically every device necessary for the repair of the trucks, and the forge shop is correspondingly well equipped. All machinery is electrically driven. For storage the commission has built a stockade inclosing a yard $5\frac{1}{4}$ acres in area, around two sides of which


C I bearing
3/8" rod continuous through hinges
Front brace 1 bar 1/2" × 2"
2'-8"
3/4"
C I bearing
4'-10 1/2"
15"
1/2"
9'-6"
PLAN
Hole in bottom of truck 15" × 2'-8." Doors extend 3/4" beyond edge of hole at end and 1/2" at side Bar 3" × 2'-9 1/2" × 1/2" riveted on one edge of door.
All parts fastened to truck body with 3/8" bolts
One cubic yard of gravel approximately within one foot of top of truck
Two cubic yards of gravel approximately within one inch of top of truck
Two tons of gravel approximately within six inches of top of truck.
Chains fastened to axle by eye bolts at right angles.
1/4" plate riveted to 2" × 2" × 3/8" Ls with 12-3/8" rivets in each L and bolted to truck with 8-3/8" bolts.
1/4" plate riveted to 2" × 2" × 3/8" Ls with 9-3/8" rivets in each L and bolted to truck with 7-3/8" bolts.
Back brace 1 bar 1/2" × 2"
Plate on bottom of angles
4'-11"
3'-0"
6"
4"
LONGITUDINAL SECTION
C.I. bearing
3/4"
5"
2"
6"
3'-7"
END SECTION
Drop doors fastened by three strap hinges. Edges of door extend 3/4" beyond edge of hole.
Operators platform - 2 Ls 4" × 12" × 1/2" - 2' wide, 1'-0" apart bolted to truck by 4-3/8" bolts and 1 board 1" × 12" × 2'-6" bolted to Ls by 4-3/8" bolts.

IDAHO PLANS FOR THE CONVERSION OF AMMUNITION BODIES INTO HOPPER BODIES.

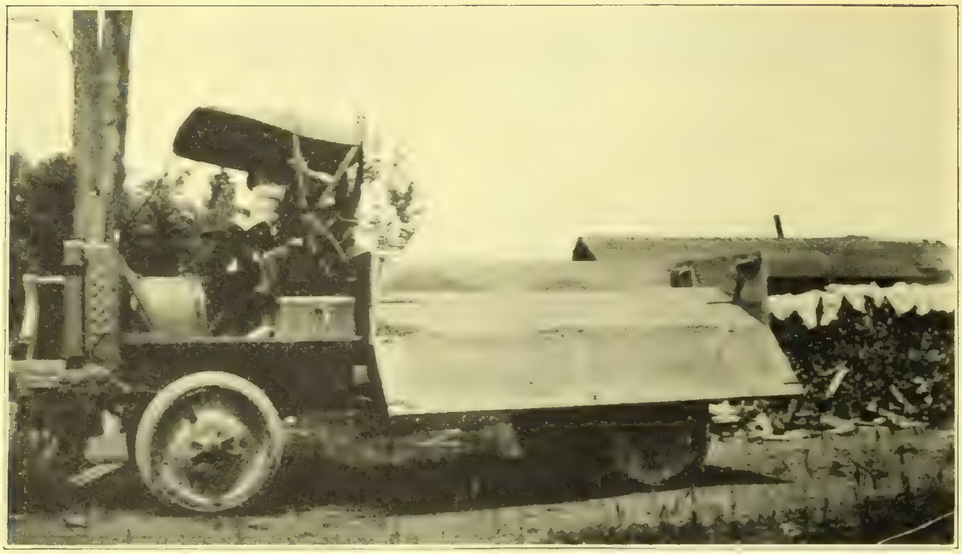


ABOVE, MISSISSIPPI TRUCK EQUIPPED WITH STANDARD BODY AND HAND HOIST. BELOW, VERTICAL HYDRAULIC HOIST ON A WISCONSIN TRUCK.

wooden sheds have been constructed to shelter the machines. There is space in the sheds for the storage of about 50 trucks. While this method of storage is probably not desirable for trucks which are to remain idle for long periods, such as during the winter, it is entirely adequate for trucks which are in active service. The entire plant, including shops and stockade, views of which are shown on pages 17 and 19, cost approximately $50,000.

Vermont's plant, which is similar to that of Utah, is constructed on a 5-acre lot which the State has bought on the State road and trolley line between Montpelier and Barre and just beyond the city limits of Montpelier. The present buildings, shown on page 3, consist of a garage 48 feet wide by 64 feet long; a machine shop, 24 feet square; a storeroom for supply parts with floor dimensions of 24 and 60 feet; a power plant, 18 by 30 feet in size; and the sheds built inside the stockaded inclosure, containing 47 stalls, the majority of which are 10 feet wide by 23 feet 6 inches deep. All buildings and sheds are of frame construction. It is also intended to build a caretaker's house in connection with the garage, but this work will not be done before the coming summer. To cover the cost of this plant, as well as the expense of freight shipment and repair of the trucks and other surplus war material, the board of control has apportioned $75,000 to be used in addition to other available highway funds.

The Montana plans include a tile machine shop, which is now nearing completion at Deer Lodge, and shed room for 40 machines. The shop building will be 120 feet long by 40 feet wide, and will include a storeroom for parts and supplies, 20 feet wide by 18 feet long. At present a large number of trucks are housed in a stockade 150 feet wide by 200 feet long, with a 20-foot shed around three sides, and the balance are outside, with the axles blocked up to lift the wheels from the ground.



SIMPLE SIDE-DUMPING WOODEN BODY INSTALLED IN MAINE.

PENNSYLVANIA AND MAINE PLANS.

Pennsylvania's storage facilities are not yet ready for use. However, the State highway department has contracted for the erection of five large buildings constructed with steel frames covered with corrugated galvanized-iron siding and roofing. These buildings are now under construction, and some idea of the general layout may be obtained from the upper view on page 5.

Maine has not progressed as far as Pennsylvania in preparing for the permanent storage of its trucks, but the elaborate plans which have been prepared give promise of a most useful plant when it is completed. A central garage and service station will be erected at Augusta early this season, and it is probable that at least two and probably four substations will later be erected at other points in the State. The Augusta plant will include a two-story fireproof shop building of concrete and steel construction and at least two garages. The site of the shop lies at the edge of a bank, which makes it possible to provide a street entrance to both floors. Each floor will have an area of 100 square feet. The lower floor will be partly underground, and will be used entirely for dead storage, with the exception of a small room reserved for the heating plant. On the second floor there will be an office 16 feet square, a combined parts stock room and tool room 30 feet wide by 60 feet long, and the rest of the floor will provide space for repair work. The two garages will be 150 feet long by 50 feet wide, and will be built to face each other with a common driveway 50 feet wide running between them, along their long dimension. Opening on the common driveway will be a series of doors, which will make it possible to reach any truck stored in either building by moving only the truck in front of it, and it will permit the moving of half the trucks without disturbing any others. Eventually the storage space can be expanded by the erection of another building 150 or 200 feet long and 50 feet wide. The plan also contemplates the erection of a paint shop 50 feet square, adjoining and communicating with one of the storage garages, which seems to indicate that the Maine commission intends to keep its equipment in good order.

HOUSING IN OTHER STATES.

Other States which have not announced plans for the construction of new buildings especially designed for the housing of the trucks have nevertheless made adequate provision for their shelter. Illinois, Indiana, Nebraska, Ohio, and Oregon have arranged to house all their equipment at State fair grounds; and New Jersey and North Dakota have made this arrangement for a part of their equipment. New Jersey has installed most of its equipment in a building which it has leased for the purpose, in connection with which it has a well-equipped shop. North Dakota houses the balance of its allotment in private garages. A similar arrangement has been made in Connecticut and Maryland. Colorado has converted an abandoned car barn; Michigan uses an abandoned motor-truck manufacturing plant; New Hampshire has converted an old stable; Tennessee has acquired a large frame building in good condition; and Rhode Island has rented facilities for the purpose.

CONDITION OF TRUCKS RECEIVED.

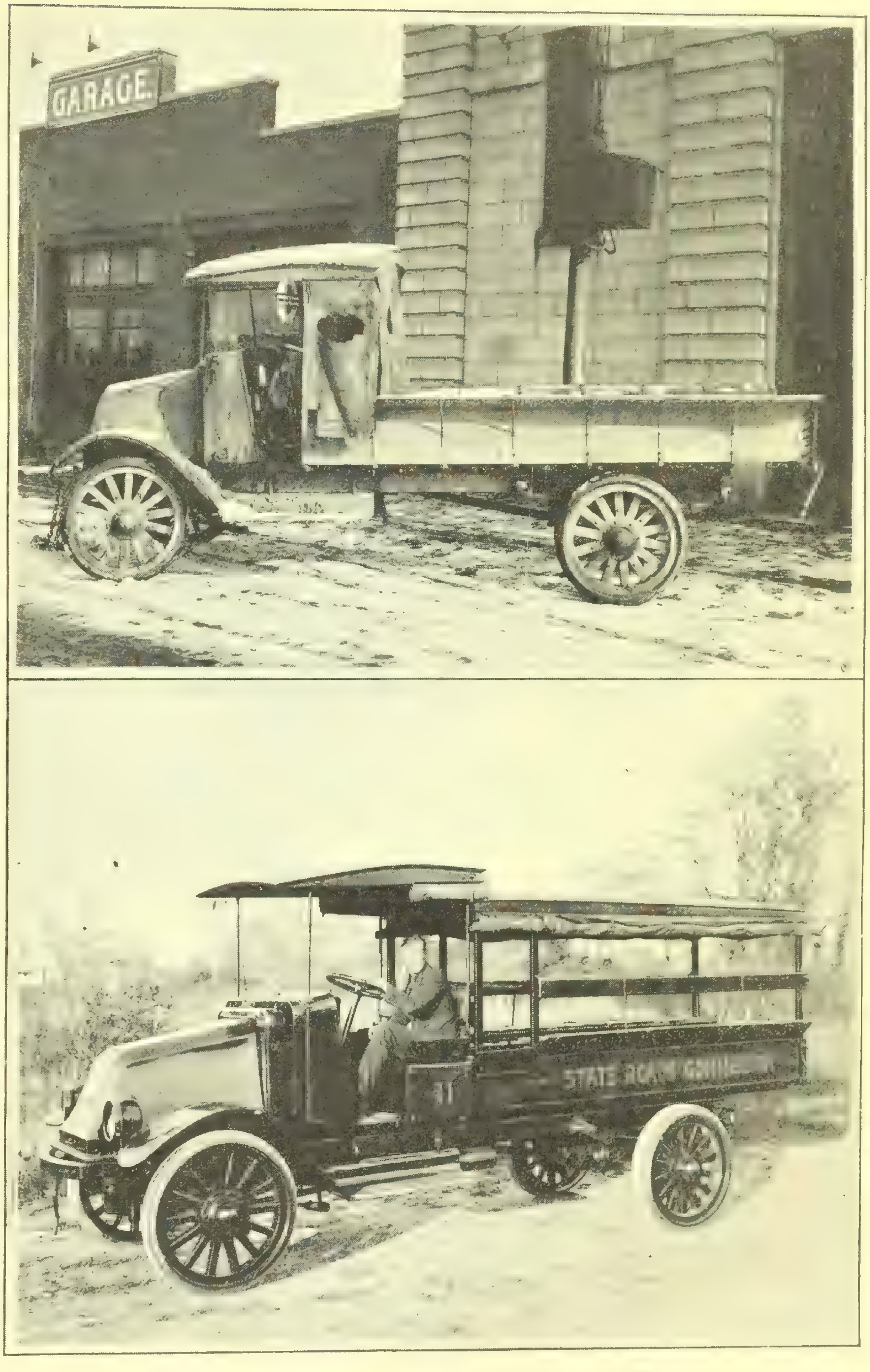
Very few of the State officials comment on the condition of the equipment received. A few, however, refer to the fact that some of the trucks and tractors were in bad condition when they arrived at their destination. The highway commissioner of South Dakota described the condition of his allotment of used tractors as "very bad * * * , largely due to carelessness," adding "that tractors loaded in Florida were not drained and reached their destination frozen solid, with the usual results." Both Delaware and Connecticut have found three or four of their allotment to be in unserviceable condition. But that this condition is not at all general is shown by a tabulation submitted by the highway commissioner of Vermont, which gives a statement of the garage expense of the trucks before they were put into service. In the case of one truck this expense was only $7.80. The greatest expense for any truck was $20.14, and the average expense for 17 trucks was only $13.61. West Virginia estimates the cost of conditioning at $75 per truck.

BODY ALTERATIONS MADE BY STATES.

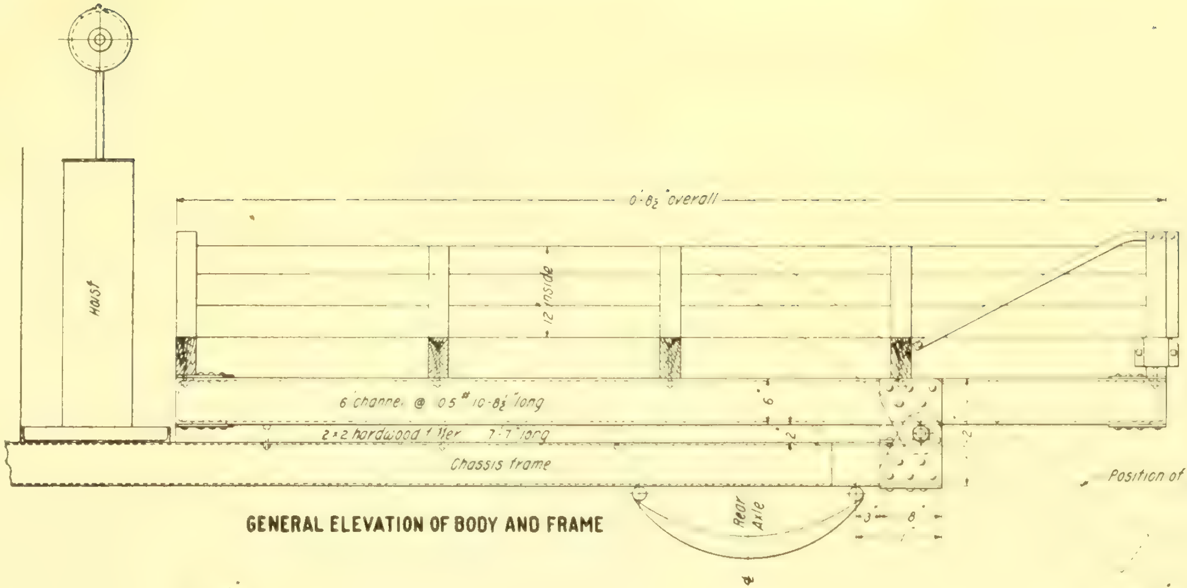
It has been the general opinion of State officials that the bodies with which the trucks were equipped for Army use are not suitable for road work. Accordingly, nearly all of them have made plans for the alteration of the Army bodies or the installation of entirely new bodies and hoisting apparatus, and a great many trucks have already been thus reequipped.

By far the larger number have been equipped with stock bodies made by various manufacturing concerns, and such trucks, in general, are also provided with patented hoisting apparatus to dump the body. Several types of such bodies and dumping apparatus are shown in the illustrations. The hoists in use for elevating the bodies are operated by hand or by hydraulic pressure. Hydraulic hoists are made in three principal patterns, two of which carry the cylinder under the body and differ mainly in the detail that the cylinder of one is hung in the vertical position and that of the other is placed horizontally. Views of these types are shown on pages 9 and 16. The third type of hydraulic hoist, shown on page 13, consists of a cylinder and plunger set up vertically between the cab and the body, the body being hung to the plunger by means of cables. The cables, slung over two pulleys at the end of the plunger shaft, eliminate the effect of eccentricity of load. Typical hand hoists, which have been applied to more trucks than any of the hydraulic hoists, are shown on pages 9, 13, and 23.

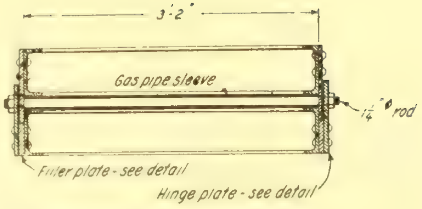
Some of the States have not had sufficient funds to install the elaborate equipment supplied by commercial body builders. Iowa, for example, has been able to equip so far only seven of its trucks because of a lack of authority to spend money for the



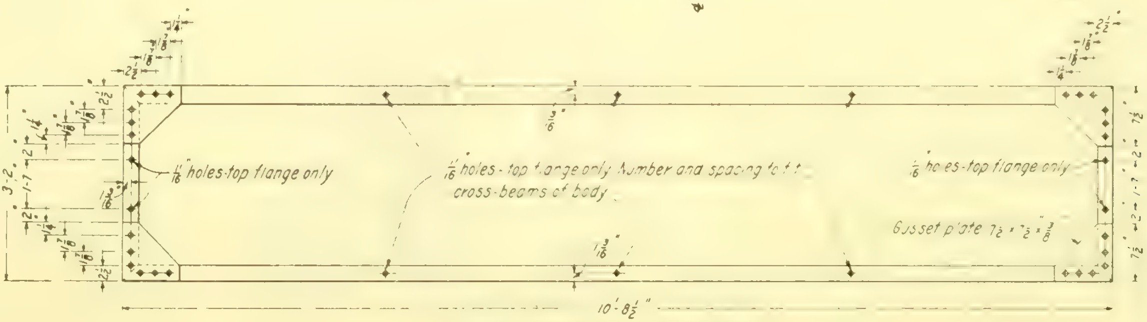
ABOVE, 2-TON INTERNATIONAL TRUCK AS RECEIVED FROM THE GOVERNMENT. BELOW, THE SAME TRUCK CONVERTED INTO A SURVEY CAR BY THE MARYLAND STATE ROADS COMMISSION.


0'-8½" overall
Hoist
12 inside
6 channel @ 10.5# 10-8½ long
2×2 hardwood filler 7'-7" long
Chassis frame
Rear Axle
Position of body at maximum height of hoist

GENERAL ELEVATION OF BODY AND FRAME

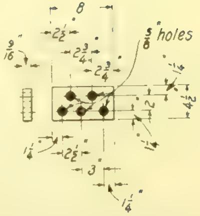


CROSS-SECTION THROUGH HINGE


11/16" holes-top flange only
11/16" holes - top flange only Number and spacing to fit cross-beams of body
11/16" holes-top flange only
Gusset plate 7½ × 2 × 3/8
3'-2"
10'-8½"

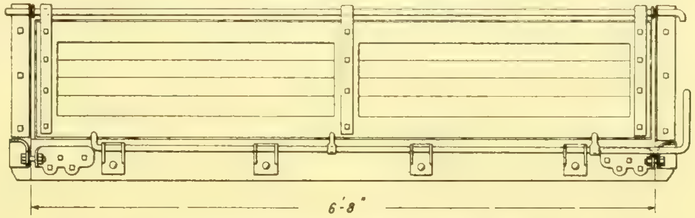
Bottom view same as top except as noted

PLAN OF LIFTING CHANNEL FRAME



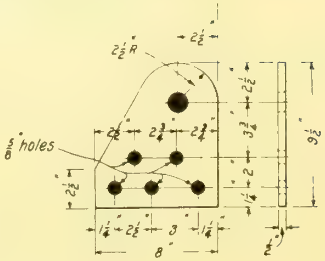
DETAIL OF HINGE FILLER

2 THUS - 8" × 4½" × 9/16"



REAR VIEW OF BODY SHOWING TAILBOARD

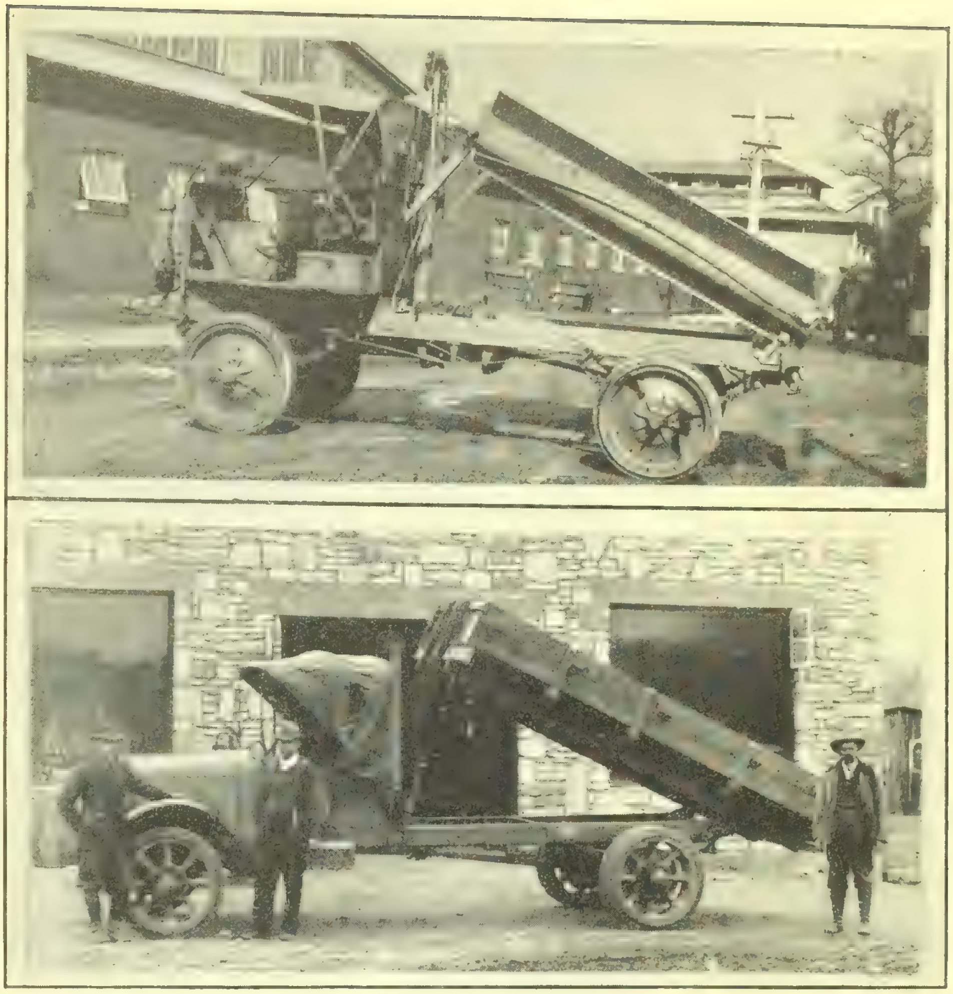
(OPERATED FROM SEAT)



DETAIL OF HINGE PLATE

4 THUS - 9½" × 8" × ½"

MAINE PLANS FOR THE ALTERATION OF CARGO BODIES.



ABOVE, VERTICAL HYDRAULIC HOIST AND DUMP BODY INSTALLED BY WISCONSIN. BELOW, CONVERTED CARGO BODY AND HAND HOIST INSTALLED BY HOLLISTER-KIRBYVILLE SPECIAL ROAD DISTRICT, MISSOURI, AT COST OF $275.

purpose. In this case the State expects to pay for the necessary equipment from the earnings of the trucks it will rent during the coming season. In other cases it has been thought desirable to devise ways to convert the bodies with which the trucks are equipped when they are received or to build single bodies to replace them. Many and interesting are the devices which the several States have put into use with this thought in mind.

One of the simpler forms of dump body is the type which has been used to some extent in Alabama, West Virginia, Tennessee, and Maine. A V-shaped ridge running lengthwise of the truck is built inside the standard cargo body, the sides of the ridge sloping to the bed of the box at the sides. Then all that remains to be done is to hinge the sides of the cargo body either at top or bottom, and the result is a side-dumping body at a cost which may be $20 or $50, but, at any rate, is very small. The usefulness of the body thus converted may be enhanced by lining the inside of the body and covering the ridge with sheet metal, which will cause the load to run off the sloping bottom more rapidly.

A view of this arrangement as used in Maine is shown on page 10, and a variant form used in Vermont is shown on page 20.

The hopper body with hand-operated bottom dump, into which Idaho has converted the steel ammunition bodies on Nash quads, has already been described. The cost of this alteration is only $85, yet it would seem to suffice for many purposes as well as much more expensive equipment.

Maine has devised a scheme of altering the standard cargo body furnished on the Packard, Peerless, and heavy aviation trucks somewhat as follows: The sideboards are cut down to 12 inches in height: a swinging tailboard hinged at the top, with provision for opening from the seat, is added at the rear, and the entire body is lined with sheet steel of 9 or 10 gauge. The front end of the body is cut off some 18 or 20 inches to allow room for mounting a hydraulic hoist between the cab and the front of the body as cut down. Cutting the body at the front end preserves the proper relation between the cross members of the body and the wheels. The cross members of the original body are bolted to a lifting frame, made up of $10\frac{1}{2}$-pound 6-inch channels, which is hinged on a $1\frac{1}{4}$-inch pin at the rear of the chassis frame. A 2 by 2 inch hardwood filler is bolted to the top of the chassis and supports the lifting frame in the normal position. All these details, with full dimensions of the critical parts, are shown on page 12. A similar arrangement, employing a hand hoist and wooden underframe, is shown on this page. It is estimated that the cost of making the body changes indicated will be about $150 per body. This does not include the cost of the hoist.

SPECIAL TYPES OF BODIES APPLIED.

Some of the States have equipped the trucks with bodies designed for special purposes. For example, New Jersey has converted an ambulance into a survey car: Maryland has accomplished much the same result with a 2-ton International as raw material. The truck before and after alteration is shown on page 11. By simply installing seats in the ordinary cargo body and covering the box with a bow frame and canvas cover, New Jersey prepares a vehicle for the transportion of State convicts to and from the prison in Trenton.

Massachusetts has added tanks and pressure spraying devices to 12 of its allotment; and New Jersey and Delaware have equipped a number of trucks with snowplows and are fully satisfied with the result.

COST OF EQUIPMENT.

The cost of the changes which the States are making in the trucks as received varies from about $20 to over $700 per truck for the various forms of body, dumping apparatus, etc. The forms of alteration and equipment are so numerous and variable that it is impossible to describe them all, so they have been listed in the table below, and the actual or estimated cost of each form of equipments has been given whenever the information is available.

Types of truck body alteration and equipment, with costs, as reported by various States.

State.	Description of body equipment.	Cost per truck.
Alabama	No accurate data	$25.00-$500.00
Arkansas	do	
Colorado	2-ton dump body and horizontal hydraulic hoist	571.50
	3-ton dump body and horizontal hydraulic hoist	663.60
	3½-ton dump body and vertical hydraulic hoist mounted at front of machine	787.00
Connecticut	2-ton dump body and hand hoist	311.25
	3-ton dump body and hydraulic hoist	797.00
	Inclosed cab (installed)	130.00
Delaware	2-ton dump body and hydraulic hoist	500.00
Georgia	2-ton dump body with vertical hydraulic hoist installed at front of machine	526.50
	3-ton dump body with vertical hydraulic hoist installed at front of machine	576.90
Idaho	2-ton dump body with horizontal hydraulic hoist	650.00
	Hand-dumping, hopper body, 2-ton (improvised)	
Illinois	2-ton dump body and hydraulic hoist	525.00
	3-ton dump body and hydraulic hoist	575.00
Ohio	2-cubic-yard dump body with hydraulic hoist	450.00
	3-cubic-yard dump body with hydraulic hoist	470.00
Iowa	Dump body	150.00
Kentucky	No accurate data	
Maine	A-frame wooden body	35.00
	Altered cargo body with vertical hydraulic hoist mounted at front	450.00
	Altered steel ammunition body with vertical hydraulic hoist mounted at front	500.00
Maryland	No data	
Massachusetts	Dump body and hydraulic hoist	700.00
	Tank and pressure spray	1,000.00
Mississippi	Steel dump body and hand hoist	500.00
Michigan	Dump body and hydraulic hoist	590.00–750.00
Missouri	Wooden A-frame dump body	47.00
	Steel dump body and hydraulic hoist	784.00
	Water tank on Nash quad	180.00
Montana	2-cubic-yard dump body and hydraulic hoist.	620.00
	3-cubic-yard dump body and hydraulic hoist.	760.00
Nebraska	Sloped bottom wooden body	150.00
	Altered ammunition body and hydraulic hoist	650.00
Nevada	Dump body and hoist	580.00
New Hampshire	2-ton dump body and hand hoist	175.00–350.00
	3½-ton dump body and hydraulic hoist	500.00–700.00
New Jersey	Steel dump body and hoist	600.00
	Snowplow attachment installed	300.00
New Mexico	Dump body with hydraulic hoist	412.00–430.00
New York	3-ton dump body and hydraulic hoist	600.00
North Dakota	No data	
Ohio	do	
Oklahoma	do	
Oregon	2-ton dump body and horizontal hydraulic hoist	425.00–475.00
Pennsylvania	35-cubic-foot dump body and hand hoist	$313.00
	54-cubic-foot dump body and hydraulic hoist.	$540.00–560.00
Rhode Island	2-ton dump body and hand hoist	300.00
	3-ton composite body and hydraulic hoist	722.00
South Dakota	2-ton dump body and hydraulic hoist	550.00
	3-ton dump body and hydraulic hoist	600.00
Tennessee	A-frame wooden body	20.00–55.00
	Steel dump body and horizontal hydraulic hoist	715.00–750.00
Texas	No accurate data	
Utah	Altered Nash quad body with hand hoist	265.00
	3-ton steel dump body and hydraulic hoist	717.00
Vermont	Altered Nash quad body with vertical hydraulic hoist mounted at front	394.00
	Side discharge wooden body for Nash quad	135.00
Washington	No accurate data	
West Virginia	2-ton dump body and hydraulic hoist	630.00
	3-ton dump body and hydraulic hoist	690.00
Wisconsin	2-cubic-yard dump body and hydraulic hoist.	525.00
	3-cubic-yard dump body and hydraulic hoist.	575.00

PENNSYLVANIA ROAD WORK.

In 1919 the State highway department of Pennsylvania completed construction work on 253.1 miles of durable highway and 41.58 miles of uncovered base. During the year contracts were awarded for 685.02 miles of durable road of various type, of which 179.74 miles were entirely completed by the close of the season. Contracts were carried over from 1918 for 95.47 miles, of which 73.36 miles were completed during 1919. Many miles of the new road building under the 1919 contracts will be completed early this year, as grading and drainage have been finished and materials for the uncompleted work are largely on the ground.

Contracts to be let during 1920 will run up to about 800 miles, and the policy is to let them at as early a date as possible so work can be started as soon as the weather and other conditions permit.

NEW YORK HIGHWAYS.

The Chamber of Commerce of the State of New York has approved a report of its committee on the construction of State highways and submitted it to the governor and the legislature. It favors the adoption of a complete system of State highways, new roads and improvements of old roads to be made with the most durable material known to engineering science. The main factor to be considered in road improvement is the annual cost of maintenance. A complete system for New York, the report holds, should consist of 13,000 miles, which, if constructed of the best material, would represent an annual cost for maintenance of $3,500,000, or $250 a mile. This is $750 less than the present average cost of maintenance. To create such a system there must be spent $167,000,000 in the construction of 4,175 miles of new roads and $36,000,000 for placing existing highway mileage in first-class condition.

HANDLING FEDERAL EQUIPMENT AFTER ITS RECEIPT BY STATES.

ROLLEN J. WINDROW, State Highway Engineer of Texas.

WHEN we were notified by the Chief of the Bureau of Public Roads that Congress had authorized the Secretary of War in his discretion to transfer to the Secretary of Agriculture for distribution among the States all available war material, equipment, and supplies not needed for the purposes of the War Department, but suitable for use in improvement of highways, little did we realize the magnitude of this appropriation and the far-reaching effect of the provisions of this act on the road-building undertaking throughout the country, nor did we fully appreciate the tremendous job with which we were confronted in receiving and distributing this vast amount of equipment among the various political units of the State of Texas.

The importance which this appropriation of equipment bears to the road building program of the various States may vary, depending on the financial and material resources of the several State highway departments, but as the basis of distribution is the same as for the distribution of Federal aid, and each State is assured of its proportionate share, it goes without saying that this is a matter in which every State is vitally interested.

In discussing the receiving and distribution of this equipment, organization methods, and rentals, I am forced to recount largely the way in which this is handled in my own State.

BASIS OF OPERATION.

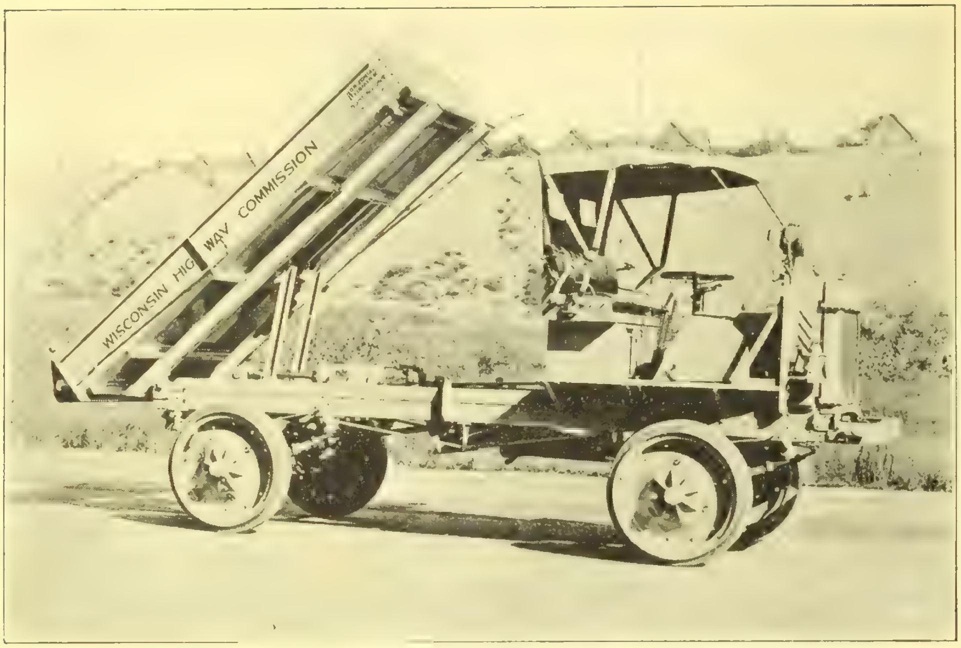
The highway departments of the various States operate on two different bases. In some dozen or more States the State highway department has the initiative in all matters pertaining to the construction and maintenance of their State highways, or, in other words, the highway departments in these States have actual charge of the engineering and construction work. In the other States which constitute the large majority the initiative in State highway work rests with the county, parish, or township, and the State highway department functions only in a cooperative or supervisory capacity.

The use, therefore, of this equipment is on a different basis in the different States, but certain it is that this equipment does not further the road building program until it is put in the hands of the operator, whether that operator be the construction division of the State highway department or whether it be the county, parish, or township. In Texas the county is the operator, and therefore our organization and plan for handling this equipment has been formulated with the main idea of getting it in the hands of the counties as soon as possible and with the least possible expense.

ROLLEN J. WINDROW.

In this discussion it is well to divide the Federal equipment into two general classes, which in most cases are to be considered and actually handled separately. Obviously, these two classes are: First, trucks; and second, all other equipment. At present the allotment of trucks constitute the bulk of the Federal equipment distribution.

If the distribution of trucks goes through as already allotted the needs of the various States will be satisfied to considerable extent, if not wholly so; but trucks constitute only one item of equipment that is used in highway work. While our needs for trucks may be largely supplied, it is useless to expect that we will receive all we need of other such items as portable crushers, road graders, steam shovels, rollers, tractors, concrete mixers, locomotive cranes, industrial track, and the hundreds of other items of miscellaneous equipment. Therefore, it appears that the distribution and use of the trucks will be on an entirely different basis from the distribution and use of the other equipment.



DUMP BODY AND HORIZONTAL HYDRAULIC HOIST INSTALLED BY WISCONSIN.

The first definite information received by the States on which they could begin to plan an organization was included in the circular letter sent out by the Bureau of Public Roads on April 19, 1919, in which it was indicated that approximately 20,000 trucks would be available for distribution to the States.

In May the State Highway Department of Texas created a separate division of the department, known as the Federal equipment appropriation division. A man was placed in charge of this division with the title of superintendent, and his duties related solely to the handling of the Federal equipment. Necessary clerical force was at once employed and as the distribution progressed field inspectors, mechanics, and laborers were employed.

PLAN OF DISTRIBUTION AND USE.

The first task confronting the Federal equipment appropriation division was to work out a plan of distribution of this equipment to the counties and to formulate regulations in regard to its use. It was decided that the equipment should be distributed to the various counties on a lease basis, and that the counties should be required to execute a legal lease agreement, acknowledging accountability for the property received by them, and stipulating the conditions under which this equipment is to be used.

It was also decided that the counties must bear the full expense of receiving and distributing the equipment, since they are the ones benefited by this appropriation. To protect its interest the highway department considered it necessary to provide for a regular inspection of the equipment after it was placed in the hands of the counties, therefore, the counties, besides paying reimbursement of receiving charges, were also required to pay an annual rental to cover the cost to the highway department of administering the control and inspection. It has been estimated that a rental of $2 per month on trucks will be sufficient to cover this cost and this is the rental which the counties are required to pay up until the end of the first fiscal year. At the end of that time this rental may be increased or decreased as found necessary and desirable.

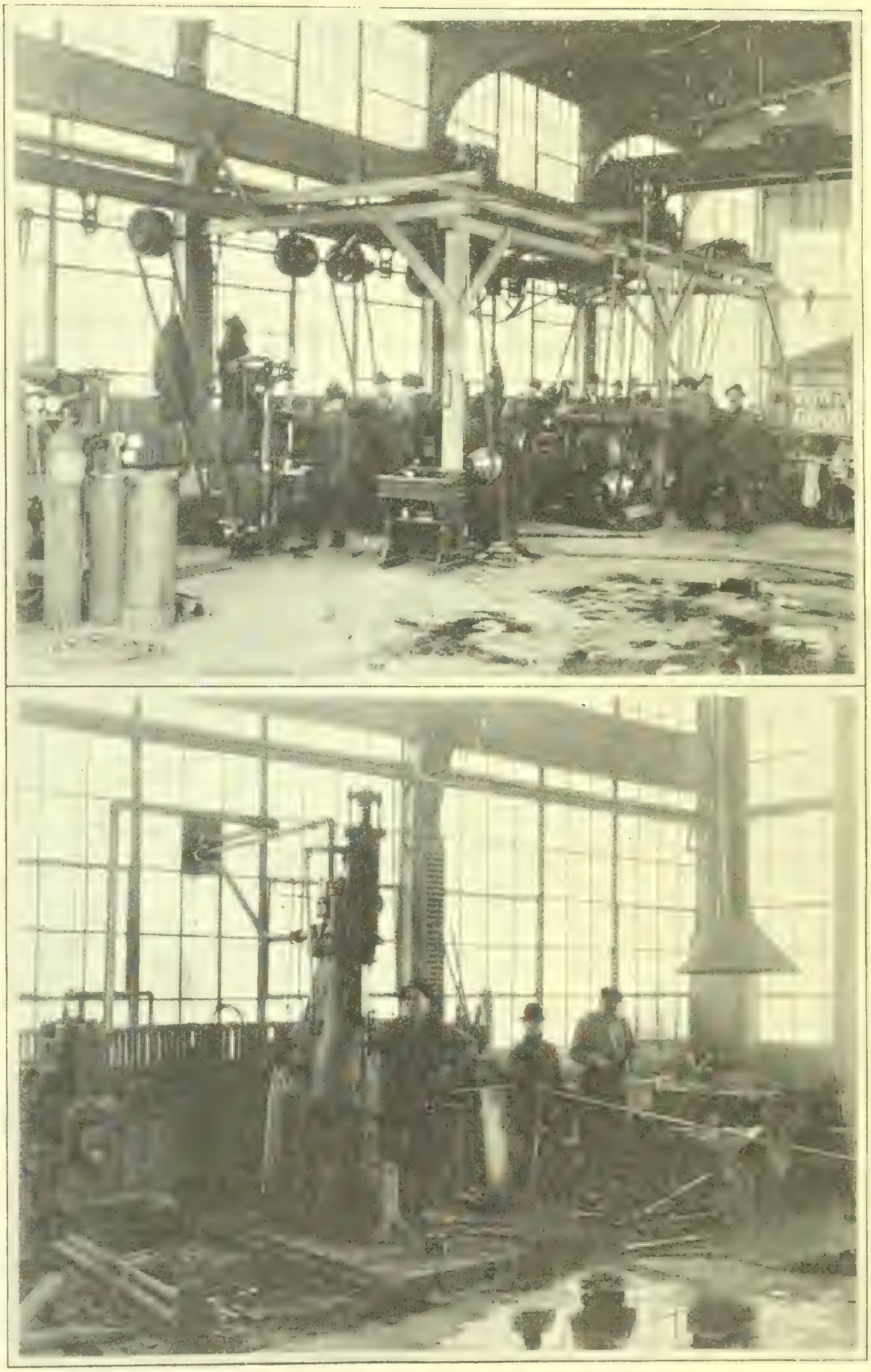
On the basis of the States receiving 20,000 trucks Texas might expect 6 per cent, or 1,200 trucks. Assuming that some of these would turn up unserviceable, that others would be needed in handling the Federal equipment, and still further reserving a surplus for unexpected contingencies, it seemed safe to take 1,000 as the number which the counties might safely expect to receive. Using this as a total number, a table of distribution percentages was worked out for each of the 253 counties in Texas. The basis of this distribution is similar to that used by the Bureau of Public Roads in apportioning aid among the States.

The various counties of the State were offered officially the number of trucks to which they were entitled under this table. In replying to this offer, the counties were asked to submit their requests in the form of answers to a questionnaire, which gave definite information as to the number of trucks the county would accept, whether less than or in excess of their allotment, information as to mileage of roads in their counties, expended and contemplated bond issues, amount of the annual road and bridge fund, data in regard to the organization for road work, and other pertinent information. As other States have probably found, in dealing with county authorities it is exceedingly difficult to get information from all counties on any subject whatever. The State highway department of Texas used this opportunity, where it was giving something to the counties as the best means of getting a large amount of miscellaneous information long desired and which we had been unable to obtain from all counties. The plan has been almost uniformly successful and there are only a very few of the counties which have not fully and gladly replied to our questionnaire.

THE LEASE AGREEMENT.

Regulations governing the use of the trucks are embodied in the lease agreement. The important points of this are as follows:

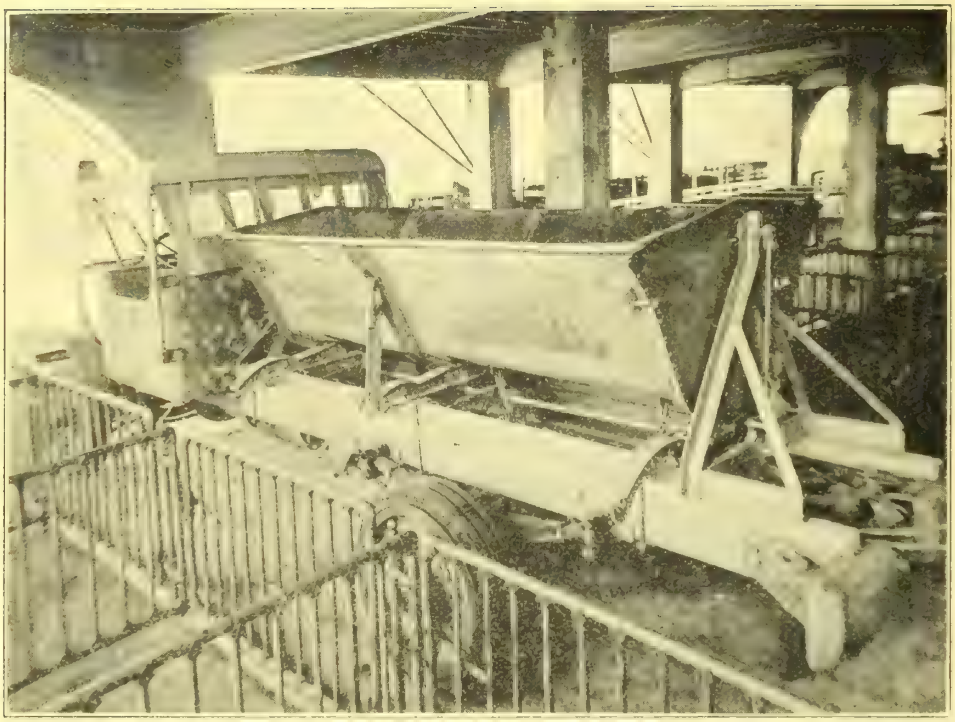
1. The truck is identified by State registration number, motor number, and serial number, and by make and capacity.
2. Every item of equipment furnished on the truck is listed in the lease agreement and the county assumes full accountability for this equipment. This provision protects the State in case it is later found necessary to recall the truck from the use of the county.
3. The county agrees to keep the truck in a proper state of repair and good working order, due allowance being made for natural depreciation with use.
4. The truck is to be used on highway work only and on the public roads under the jurisdiction of the county commissioners' court.
5. The State highway department is to have free access to the truck at all times for the purpose of inspection, to insure that the provisions of the lease agreement are being carried out.
6. The county agrees to provide covered storage for the truck when not in use, to keep it covered with a waterproof tarpaulin, and further agrees to paint the truck once a year.
7. The county accepts full liability for the expense of receiving such equipment as is delivered to it. The county makes a payment of $150 at the time of executing the lease agreement and agrees to pay such further sum as may be later assessed. Also, at the time of executing the lease agreement the county makes a rental payment at the rate of $2 per month for the time remaining until the end of the fiscal year.
8. Provision is made for recall of the truck from the county by the State highway department upon giving two months' notice of such intent to recall and upon reimbursement to the county by the State highway department of all unearned rental and a certain per cent of the receiving charges which may have been paid by the county. The per cent of receiving charges to be refunded ranges from 100 per cent when the truck is recalled at any time up to 3 months after delivery of the truck down to 50 per cent when recalled after 27 months after delivery of truck.



INTERIOR OF SHOPS, UTAH. ABOVE, MACHINE SHOP. BELOW, FORGE SHOP.

DISTRIBUTION OF CHARGES.

In arriving at a fair distribution of receiving charges, there are several considerations involved. In the first place, counties adjacent to Camp Normoyle receive their trucks by direct convoy, and the charge entailed in receiving these trucks from the Army, making necessary repairs, and delivering to the counties may not exceed $40 to $50 per truck. On the other hand, there



ONE OF THE BODY TYPES INSTALLED BY NEBRASKA.

are some counties in the extreme western part of the State which receive trucks that were shipped by freight from points in the northeastern part of the United States, and in some cases freight alone has amounted to over $300 per truck. Another consideration involved is that on an average it will cost the State highway department just as much to receive an old worn-out 2-ton truck of an inexpensive make as it will to receive a brand new 3-ton truck of a more expensive make which may actually be valued at twice to three times the value of the cheaper, lighter truck. Manifestly, then, it would be unfair to require a county to pay the exact charges which are incurred in receiving the trucks it gets, and a more equitable arrangement would be to have each county pay the same for the same kind and type of truck in similar condition of repair. Accordingly, we will take the total receiving charges on all trucks and then assign such charge against the different makes and types of trucks as will reimburse the highway department for the full amount paid out, and every county will pay the same for the same make and type of truck. Of course, a scale of charges will be established whereby the receiving charges on the most valuable trucks will be more than the receiving charges on the least valuable.

While the details which have been enumerated were being worked out in the main office of the State highway department, the work in the field was also being put under way. A rough estimate was made of the number of trucks which will be needed in the different sections of the State and some dozen distribution points were selected as stations from which trucks could be delivered. The points were so selected that the longest drive from any distribution station to a county seat is not more than 200 miles, and the majority of county seats fall within a 100-mile radius. These stations were selected and inspectors were sent out in the field to make preliminary investigations, and when a certain town was decided upon as being suitable for our purpose the inspector made all preliminary arrangements for storage, purchase of supplies, and employment of labor. Factors affecting the selection of distribution stations were available storage space, garage and shop facilities, availability of labor, railway facilities, and highway connections to neighboring counties.

DETAILS OF DISTRIBUTION.

The State highway department at Austin receives a notice by wire that a certain number of trucks are available for immediate shipment. We then wire the Bureau of Public Roads complete shipping instructions on this shipment, which shipping instructions are transmitted through the Chief of Motor Transport Corps to the Army supply depot where trucks are stored.

The Army supply depot then ships the trucks to the distribution station ordered, bills of lading and bills for loading are sent direct to the office of the State highway department at Austin; an inspector is immediately dispatched to the distribution station, and by the time trucks arrive he is there ready to unload them. As soon as the trucks are received they are checked over and a complete list of all equipment is then sent in to the office. This is the official notice that the trucks have been received by the State of Texas, and accountability for this equipment begins at this point.

As soon as notified of receiving the equipment the highway department acknowledges receipt to the Bureau of Public Roads, to the Chief of Motor Transport Corps, and to the shipper. Bills for loading and freight bills are then approved and paid. The inspector has now employed a first-class mechanic and a sufficient number of drivers and laborers. The trucks are unloaded, under their own power, and are driven or towed to the garage or storage space at the distribution station. Here they are gone over thoroughly, are greased, oiled, have their motors tuned up, and are tried out to see that they are in first-class condition;

all necessary repairs are made; and when trucks have been tried out and are found in first-class shape they are then ready for distribution to the counties.

Several days before this the Austin office is notified by the inspector that the trucks will be ready for delivery on a certain date. Authorizations are made out in the office in quadruplicate copy. The original and duplicate are sent to the county judge with instructions to have a representative call for the trucks allotted the county on these authorizations on a certain date at the distribution station, the representative to bring these copies of the authorization with him. The triplicate copy is sent direct to the inspector as a notice to him that such and such a truck is to be delivered to a county with certain specific items of equipment on hand on a certain date. The fourth copy of this authorization is retained in the office files.

The county judge next sends his representative to the station on the date mentioned. the truck is filled with gas, oil, water, and in good running condition is turned over to the representative of the county. The equipment is checked over by both the State highway department inspector and the county's representative, and both men sign both the original and duplicate copies of the authorization, thereby acknowledging delivery and receipt of the equipment which is then transferred to the county. The county representative keeps the duplicate copy of the authorization and the original copy is sent to the Austin office immediately. The county representative takes the trucks and drives them back to his own county.

ABOVE, EXTERIOR VIEW OF UTAH'S MACHINE SHOP. BELOW, INTERIOR OF STOCKADE AND STORAGE SHEDS, UTAH.

The next step is the execution of the lease agreement. This is made up in duplicate copy in the office of the State highway department. It is then sent out to the county judge with a statement of preliminary charges against this equipment. The county judge executes the lease agreement by having it signed by the four members of the commissioners' court, and himself, and he returns both copies of the agreement to the department at Austin accompanied by a check covering the charges for which he has been billed.

The agreement on reaching Austin is signed by the State highway engineer on behalf of the State highway department. The original is kept in the office files and the duplicate is returned to the county judge. There is an extra step involved here in sending the agreement out originally unsigned and then having it returned to Austin for the signature of the State highway engineer, but this is absolutely necessary to insure this being properly done, for were the agreement made up, signed by the State highway engineer, and then sent out for the signature of the county officials, there would be numerous cases where these agreements would never be returned.

SIDE DUMPING BODY ADOPTED BY VERMONT.

At a later date when the complete charges against this equipment become known the county will be billed for the balance due on the trucks they have received. The transaction is then complete; the equipment is the property of the State highway department and is being operated by the county on a lease basis.

EQUIPPING WITH DUMP BODIES.

The experience of Texas in equipping the trucks with dump bodies is probably not that of the majority of the States, and our case, therefore, may not be of general interest. The deciding factor is a geographical one. Due to the vast extent of the State in area, it was necessary to receive and distribute trucks at more different points than in perhaps any other State. To have received these trucks all at one point and there equipped them with dump bodies and then have them again shipped out to the counties would have involved a delay and expense which hardly seemed justifiable. Likewise it was not possible to have all the trucks which were going to any one distribution station shipped to that station at one time as these trucks were urgently needed over the whole State, and had the department adopted the policy of supplying one section of the State completely at first and then proceeding to another section the neglected counties would have certainly offered very vigorous and well-justified objection. Another factor in this matter was that where a county has several trucks allotted to it, it would in all probability desire one truck as a general maintenance truck and would prefer to have the original box body with which most of these trucks are equipped. Also, as the counties were to be asked to bear the full expense of receiving these trucks, it was nothing but right that the decision as to type of dump bodies which they desired to operate and pay for should be left in their hands. Accordingly, this matter has been left entirely up to the individual counties, and they are making such selection of body equipment as they deem best suited to their needs and financial resources.

There is one phase of this matter in which the State highway department has taken the initiative. We have experimented with cutting down the steel ammunition body with which our Nash quad trucks were equipped. We have found that this can be made into a practical dump body by removing the steel body from the chassis, cutting it down with a blow torch to a depth of 15 inches, riveting a small angle-iron around the cut edge, and equipping the body with a swinging tail gate at the back end and mounting it back on the chassis with a hand hoist attached between the body and the cab. Business firms in Texas do this work and are able to supply us at a price which affords a saving of from $100 up over any other steel dump body which we have thus far been able to obtain.

OTHER EQUIPMENT.

One of the distribution stations for trucks is located at Austin, the headquarters of the highway department. This station has been expanded and is being used to receive all other equipment allotted us besides the trucks, and a permanent central organization is maintained there. The stock of spare parts which the department has received for the Nash trucks has already been shipped into this point and has been stored, inventoried, and catalogued, and a clerk is in charge of this stock and is occupied in filling orders which come in for spare parts and accessories from the various counties.

Deliveries to Texas of this miscellaneous equipment have been far behind truck deliveries, and whereas we have received about 35 per cent of our trucks to date we have only received a small fraction of the total miscellaneous equipment which has been allotted. In view of the uncertainty as to how much of this equipment will eventually be delivered, it is considered best to receive and store it at the Austin station until definite assurance is available as to exactly what quantity of each item of equipment will be received, and it is not planned to put any of this equipment in the hands of the counties until such information is at hand. As the equipment is received, it is in serviceable condition and stored, and it is not contemplated that very much of this will be delivered to the counties before next spring, when we hope that practically all that we were going to get will be in our hands.

Special regulations will be drawn up covering the use of this special equipment, but the plan will be similar to the plan under which the trucks are being used. That is, the equipment will be leased to the counties, and when the need of a particular county has ceased the equipment may be withdrawn and allotted to some other county. Accurate account is kept of the receiving charges on every different item of equipment, and counties will be required to reimburse the State highway department for all expense incurred in handling the equipment which the counties receive.

INTERIOR VIEW OF IDAHO HOPPER BODY.

RENTALS AND INSPECTION.

In the matter of rentals to contractors and force account jobs, the State highway department of Texas approves three different schemes on which this may be carried.

1. Where the equipment is available in the county at the time the contract is to be let, the county may advertise for bids on the basis of furnishing the contractor with certain specific equipment.
2. The county may lease the equipment to the contractor for a certain specified cash price, but such contracts must be submitted to the State highway department for approval.
3. The county, as a private party, may haul for the contractor on a ton-mile basis at the usual pay for such work, the county using its own trucks and drivers.

In this matter of rentals to contractors and force account jobs, every individual case must necessarily be examined on its own merits, and the division engineers of the highway department, who are in close touch with all the counties, make recommendation as to what action the department should take in each case.

The State highway department intends to exercise its control over this equipment by maintaining frequent inspections. The State is divided into eight districts, with a division engineer as the official representative of the State highway department in each district. Divisional inspectors have been put on in these districts and these men work under orders from the division engineer. Their duties involve the inspection of this Federal equipment, submitting necessary reports in regard to the use and possible misuse of it and other matters pertaining to traffic regulations and registration of the motor vehicles. The division engineer in his visits to counties also transacts some of this business, and in this way the highway department is enabled to maintain a close supervision of the use of this equipment.

The benefits to be derived by the State from the equipment that has been received and will be received from this source can not be accurately calculated. We feel that the maximum amount of good will accrue under the plan that has been adopted for its use in Texas. In our opinion, Congress did an exceedingly wise thing when it decided to distribute this equipment in this way, rather than selling it at a tremendous sacrifice to private individuals and corporations.

WEST VIRGINIA'S GOVERNOR FOR GOOD ROADS BONDS.

West Virginia next fall will vote on a constitutional amendment that will make possible the bonding of the State to the extent of $50,000,000 for the building of good roads. This is Gov. Cornwell's proposition. He wants his State to have as complete a system of articulated roads as any other. That's why he sets an example whenever he can to show his people the value of good roads.

"If we had in this country a system of good roads covering every State, railroad strikes would have no terrors for us," said the governor. "We would not then be dependent upon the whims of a few men. And it is coming. Eventually we shall have highways over which we can haul to markets all of our farm products. The development of motor trucks for heavy hauling is a matter of only a short time, and I am confident that within a decade we shall have a highway system that will make us virtually independent of the railroads in emergencies. Today, however, a railroad strike is a very serious matter. In West Virginia, for instance, there were sections which in a week or 10 days would have been entirely out of food supplies if the recent unauthorized railroad strike had continued. Good roads serving every community, large or small, would make such a situation impossible."

PAVEMENTS ON THE LINCOLN HIGHWAY.

Of the 3,223 miles of the Lincoln Highway between New York City and San Francisco, there are 801 miles classed as graded dirt, 749 miles classed as graded gravel, 244.5 miles classed as natural dirt, 207.2 miles classed as natural gravel, 17 miles classed as shale, and 13.2 miles classed as sand. The remainder of the route is paved or macadamized, the different types of surfacing and the milages being as follows: Bituminous macadam, 406.3; concrete, 317; brick, 197.8; macadam, 175; asphalt, 80.6; granite block, 7.8; and creosoted wood block, 6.6. These figures are for March 1, 1920, and were furnished by the Lincoln Highway Association.

In the foregoing classification, as well as in that arranged by States, the following explanation, supplied by Vice President Bement, of the association, should be noted:

> In order to simplify the table, we have classified all forms of concrete construction under one head, "concrete." This, therefore, includes one and two course concrete construction, and whether reinforced or not or bituminously treated or not.
>
> "Asphalt" refers only to sheet asphalt and in the table is practically all represented by city street paving traversed by the Lincoln Highway through the many municipalities. Much of the total brick mileage is also brick streets in cities.
>
> "Macadam" refers to all forms of macadam with the exception of bitulithic or bituminous macadam. Any macadam treated with anything besides water is included under "bituminous macadam."

The mileages of the different types, by States, are as follows:

New Jersey.—Asphalt, 28.5; concrete, 21.2; granite block, 7.8; creosoted block, 3.6; brick, 1.9; total, 63.

Pennsylvania.—Bituminous macadam, 266.3; brick, 40.3; asphalt, 28; concrete, 19.7; graded dirt, 14; creosoted block, 3; total, 371.3.

Ohio.—Brick, 85.3; macadam, 73.5; bituminous macadam, 54; graded dirt, 19.9; concrete, 8.9; total, 241.8.

Indiana.—Concrete, 54.4; graded gravel, 45; macadam, 31; brick, 28; asphalt, 6; total, 164.4.

Illinois.—Concrete, 75.8; graded gravel, 32.2; brick, 18.4; graded dirt, 17.2; macadam, 13.5; asphalt, 5.3; total, 162.4.

Iowa.—Graded dirt, 260.1; graded gravel, 106.5; brick, 15.2; concrete, 4.9; asphalt, 4.1; total, 390.8.

Nebraska.—Graded dirt, 313.2; graded gravel, 108.4; concrete, 9.6; light sand, 9.2; brick, 8.5; natural gravel, 8; bituminous macadam, 7.1; asphalt, 2.9; total, 466.9.

Wyoming.—Graded gravel, 193.1; graded dirt, 114.6; natural dirt, 92.5; natural gravel, 31; shale 15; concrete, 0.3; total, 466.5.

Utah.—Graded gravel, 54.8; natural dirt, 51; macadam, 40.2; natural gravel, 26; graded dirt, 24; bituminous macadam, 9.5; concrete, 7.9; sand, 4; asphalt, 2; total, 221.4.

Nevada.—Graded gravel, 182.7; natural gravel, 133.9; natural dirt, 101; graded dirt, 22; macadam, 12.5; concrete, 6; asphalt, 0.8; total, 458.9.

California.—Concrete, 108.3; bituminous macadam; 69.4; graded gravel, 26.3; graded dirt, 16; natural gravel, 8.3; macadam, 4.3; asphalt, 3; total, 235.6.

COUNTY ROAD BUILDING PROGRAM.

Adams County, Wash., will undertake the construction of 92 miles of road this year, estimated to cost $750,000. There are 77 miles of the "Donohue" roads, built under the Donohue law, to cost approximately $700,000, and 15 or more miles of county roads to be constructed by county force account, to cost $50,000 to $60,000. In addition $80,000 is to be used on road district roads. The county now has 29.5 miles of Donohue roads and 197.75 miles of permanent highways under contract which are to be completed this year. This will cost about $475,000.

DISTRIBUTION OF SURPLUS WAR MATERIALS FOR ROAD BUILDING.

By H. L. BOWLBY, Chief War Materials Division, United States Bureau of Public Roads.

THE distribution of road-building machinery, equipment, and supplies from surplus war materials to the State highway departments was made possible by an act of Congress approved February 28, 1919. This was section 7 of the Post Office appropriation act, and read as follows:

> That the Secretary of War be, and he is hereby, authorized, in his discretion, to transfer to the Secretary of Agriculture all available war materials, equipment, and supplies not needed for the purpose of the War Department but suitable for use in the improvement of highways.

DUMP BODY WITH HAND HOIST INSTALLED BY THE MARYLAND STATE ROADS COMMISSION.

It will be noted that the provisions of this act are very broad and provide the necessary authority for the transfer of any material in the possession of the War Department that is surplus and suitable for use in the improvement of highways. A letter from the Secretary of War, dated May 3, 1919, made available the first list of materials and equipment for distribution to the States, and the Director of the Division of Purchase, Storage, and Traffic was directed to turn this material over to representatives of the Secretary of Agriculture on his order.

This list was very general in its scope, covering engineering equipment, small construction tools, steam shovels, locomotive cranes, and miscellaneous road-building machinery.

The second extensive list of surplus road-building equipment was transmitted to the Bureau of Public Roads by the director of sales of the War Department in a letter dated May 24, 1919. The list was a very extensive one, covering 14 closely typewritten pages. Among the items cleared at this time were the 15 and 20 ton Holt caterpillar tractors, a quantity of office supplies and equipment, engineers' transits and levels, and miscellaneous road-building tools and machinery.

The requirements of the State highway departments were obtained by means of mimeographed copies of the list of road-building machinery, tools, and supplies furnished the bureau by the Division of Sales of the War Department. From the replies received the final distributions were made and definite shipping instructions prepared and forwarded to the division of sales.

An attempt has been made to treat all States impartially in the distribution of the material available. The shipments made by the War Department in accordance with our shipping instructions have been made in an impartial manner. The unfortunate feature has been that, due to various causes, all of the material originally cleared as being available for distribution has not been shipped. This has resulted in some of the States receiving certain classes of material and machinery which other States have not received. A rough estimate at this time indicates that approximately 10 per cent of the quantities of road-building machinery, equipment, and supplies made available at various times by the War Department have been distributed to the State highway departments. This is exclusive of motor-propelled vehicles and spare parts.

Under date of June 9, 1919, the Secretary of War notified the Secretary of Agriculture that the War Department would deliver out of the surplus in the United States or in France the equipment and supplies in the list submitted by the latter.

LIST ASKED FOR BY PUBLIC ROADS.

The list of road-building machinery and equipment requested at that time was as follows:

524	5-ton caterpillar tractors.
1,035	10-ton caterpillar tractors.
742	Engineers' transits.
797	Engineers' levels.
800	Abney hand levels.
2,500	Steel tapes.
1,200	Level rods.
500	Planimeters.
300	Drafting tables.
400	Road rollers, steam and gas driven.
700	Concrete mixers.
600	Road graders.
400	Elevating graders.
200	Sprinkler wagons.
200	Road oilers, motor-driven.
125	Derricks, 30 to 60 feet.
100	Pile drivers, complete outfits.
200	Air drills, complete sets.
250	Steam pumps, 3 and 4 inches.
150	Centrifugal pumps, with power to 4 inches.
75	Diaphragm pumps, gasoline-driven.
500	Rock crushers, complete outfits, 125 to 200 tons capacity.
200	Buckets, clamshell, orange-peel, and bottom-dump.
125	Road scarifiers.
50	Excavators, caterpillars and drag line.
700	Plows, road and railroad.
300	Plows, rooter.
25	Automotive cranes.
3,600	Trailers for tractors.
500	Miles industrial railway track.
200	Industrial railway locomotives.
3,500	Industrial railway dump cars.
200	Steam shovels, 1-yard and less capacity.
6,500	Dump wagons.
250	Conveyers, gravity and power.

Engines.

35	Donkey	from 5 to 30 horsepower.
200	Hoisting	
75	Gasoline	
375	Steam drills, complete outfits.	
250	Portable air compressors.	
100	Boilers, 15 to 30 horsepower.	
275	Electric motors, 2 to 50 horsepower.	
20	Electric blue-print machines.	

A representative of the Department of Agriculture was sent to France the first part of July, 1919, to assist the War Department in the selection of machinery and equipment suitable for road building to be returned to the United States in conformity with this list

EQUIPMENT RETURNED FROM FRANCE.

The following is a tabulation showing the road-building equipment which was returned from France in response to a cable from the Secretary of War, dated June 20, 1919, to the liquidation commission of the War Department in France, for delivery to the Department of Agriculture:

		Lake Gleal.	Lake Francoma.	Saint Naiwa.	Lake Sapor.	Peerless.	West Loquassuck.	Nyanza.	Santa Cecilia.	Cape Romain.	Chiacan.	West Gotomska.	West Kuechee.	Waxahachie.	Hoxie.	Woonsocket.	Fort Stevens.	Python.	Lambs.	West Islay.	Western Scout.	Arizonan.	Total.
Boilers, 20 horsepower										6													6
Boilers, 25 horsepower										1													1
Boilers, hoisting engine																			10				10
Buckets, clamshell			[illegible]	1			1									3							177
Buckets, orange-peel			79	8			1									8							89
Cabs, locomotive	crates			36																			36
Cab tops														17									17
Cars, 36-inch gauge							9																9
Cars, 36-inch gauge, spare parts	cases															7							7
Cars, parts	[illegible]									11													11
Compressors, air												1	1										2
Engines, hoisting														16									16
Excavators												1											1
Fuel-oil system										[1] 1													[1] 1
Graders, Austin elevating				8																			8
Graders, road							13					1	2					8	8				32
Hoists, gasoline										2													2
Hoists, steam										12													12
Headlights														3									3
Locomotives, 36-inch gauge														9	17								26
Locomotive equipment, 36-inch gauge	cases	165																					165
Mixers, concrete												11				25	16		7				59
Motors, electric		49								2			2										53
Pumps, centrifugal			9	1						10													20
Pumps, steam				3						11													14
Plants, asphalt-mixing																					11		11
Plows, railroad																	27						27
Plows, road												5	6										11
Plows, rooter												2											2
Plows, spare parts	box											1											1
Pumps																	54						54
Railroad equipment, 27 pieces:																							
Derrick parts	cases																	63					63
Drivers, flat-wheel																		2					2
Drivers, flange																		18					18
Rim, flat-wheel																		1					1
Tubes, boiler	crates																	6					6
Rollers, road																				8			8
Tenders, locomotive	cases													2	17								19
Tenders, 36-inch gauge locomotive	do			3												1							4
Tenders, 36-inch gauge locomotive, spare parts	do															9							9
Tractors, 2½-ton						5																	5
Tractors, 5-ton								107	2													14	[1] 123
Tractors, 5-ton Reo					[1] 29						16												[1] 45
Tractors, 10-ton						71		21														46	[1] 138
Tractors, 10-ton Holt					3						1												[1] 4
Trucks, 36-inch gauge			44																				44
Trucks, 36-inch gauge tender				4										4									8
Tractors																	18						[1] 18
Tractors, Cleveland																			2				2
Trees																		11					11
Underframes, 36-inch gauge										6													6
Wagons, dump		52	76									41	41					32					242
Wagons, Watson dump				21																			21
Wagons, dump-parts	cases						379																379
Wagons, dump, poles for																		18					18
Wheels																		70					70
Yokes, neck																		4					4

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[1] Refused to release.

[2] With pumps.

TRANSFERRED TO APRIL 1, 1920.

The following statement shows all of the miscellaneous war materials, supplies, and equipment that have been transferred from the War Department for road-building purposes up to April 1, 1920:

Axles, dump-wagon		9
Boilers:		
Various horsepower		9
20-horsepower		7
25-horsepower		5
Thew		1
Loeffel 30-horsepower		1
Boxes, engineers' transit		2
Bridges, steel highway		1
Brooms, stable		5,653
Buckets:		
Clamshell		150
Orange-peel		113
Concrete-mixer		4
Buggies, Lakewood:		
6 cubic feet		96
8 cubic feet		38
Cameras, 3¼ by 5½		60
Carpenters' shops, portable		10
Cars:		
Dump, 4-yard		4
Western side-dump, 24-inch gauge		2
Standard steel cradle		6
Car:		
36-inch gauge bodies and parts		23
Koppel, 3 cubic yards		12
Trucks, 36-inch gauge		34
Underframes, 36-inch gauge		111
Carts:		
Lumber, 36-inch gauge		12
Concrete, push, ⅓-yard		79
Concrete, Imsley		10
2-wheeled dump, 1-horse		10
2-wheel, water, 150-gallon		36
Chains, surveyors':		
300-foot		1
100-foot		1
Chains:		
Stanley hook skid		777
Antiskid	sets	7,800
Compasses, box		200
Compressor:		
Gardiner Rex		1
Portable air		3
Conveyor, power		1
Crane:		
Byer's auto with clamshell bucket		4
Traveling, 10-ton		1
Crowbars		150
Crusher, stone, single-roll, Jeffery Manufacturing Co		1
Derricks, various		35
Derrick, 2-ton, stiff-leg		1
Derricks, 5-ton		19
Detonators, Nos. 6 and 8		3,653,350
Drills, air:		
Little David		1
No. 4		4
Dynamite, 60 per cent, low-freezing		4,000
Engines, gas, miscellaneous		2
Engines:		
Hoisting Mundy		1
Gas, 3-horsepower pump, 4 by 5 inches		6
Engine:		
10-horsepower Novo-gas		1
Hoisting		47
Excavator		1
Exploders		68,940
Forges:		
Blacksmith		1
Portable		1,836
Forks, stone		37
Frames, saw, portable		20
Generator, Delco, ¾-kilowatt		10
Graders:		
4-wheel		16
Elevating, Austin		29
Handbook:		
Heavy aviation		167
F. W. D		30
Nash quad		195
Handle:		
Ax		6
Mattocks		50
Sledge, 30-inch		12
Harrow, disk		1
Hatchets		650
Hoes:		
Grub		316
Mortar		69
Hoist:		
Chain, 2 and 3 ton		14
3-drum and boiler		4
9 by 10 inches		7
Gas		1
Steam		8
Electric, 35-horsepower		1
7 by 10 inch, double-drum lift, boiler		12
Steam, boiler, and swinging engine		5
Hopper:		
2-way gated		2
20-foot Ransome		2
Jacks, 25-ton telescopic, screw		68
Kettles, tar		5
Lanterns, railroad combination		6,937
Level:		
15-inch engineers'		4
Engineers'		180
Builders' wye		1
Hand		1
Wye		21
Locomotives, 36-inch gauge		20
Machine:		
Parson, back-filling		1
Trenching, Parson, 36-inch		1
Mattocks		2,100
Mauls:		
Spike No. 10		2
No. 12		22
No. 16		5
Mill-crushing, Allis-Chalmers, 2-roll		1
Mixers, concrete:		
Miscellaneous		90
Foote, No. 40		3
Milwaukee, ¼-yard		1
Steam-driven		2
Smith		3
Ransome, 1 cubic yard		11
Ransome, ½ cubic yard		1
Koehring, 30 cubic foot		1
Lakewood, ¾ cubic yard, steam		1
Motors, electric:		
1½-horsepower		1
2-horsepower		2
3-horsepower		7
4-horsepower		1
5-horsepower		29
7½-horsepower		3
10-horsepower		6
12-horsepower		1
13.6-horsepower		5
15-horsepower		11
16.5-horsepower		1
20-horsepower		4
32-horsepower		3
40-horsepower		3
41-horsepower		2
50-horsepower		7
55-horsepower		1
75-horsepower		2
85-horsepower		9
D. C., 1,100 to 1,600 r. p. m.		1
125-horsepower		1
Motorcycle, Cleveland		158
Parts, spare:		
Buick	lots	5
A. P. buckets	sets	6
Car, 36-inch gauge	cases	513
Diamond T	lot	1
F. W. D. brackets for tops		598
F. W. D tops with curtains		598
Ford	lots	4
G. M. C	do	4
Heavy aviation, 3-ton	lot	1
Hudson Super Six	do	1
International 2-ton	do	1
Locomotive, 36-inch gauge	cases	41
Kelly-Springfield	lot	1
Moreland	do	1
Nash 2-ton	lots	49
Nash, tops and curtains	sets	408
Overland	lots	2
Packard	lot	1
Pierce Arrow	lots	10
Selden	lot	1
Holt tractor, 75-horsepower	lots	2
Trailer, 15-ton	cases	25
Velie	lot	1
Whites, 5 and 3 ton	lots	2
Wilson	lot	1
Picks		1,768
Pipe:		
Iron water	feet	4,013
Cast-iron		
12-inch, 4-foot length	do	500
18-inch	do	2,000
24-inch	do	422
36-inch	do	363
Planimeters		131
Plants, asphalt		11
Plows:		
Road		106
Tractor, 14-inch		8
Poles, range		3
Posts, fence		77,900
Powder, black blasting No. 3F	pounds	1,450,000
Pumps:		
Barnes Novo, 6-horsepower		30
Blackmer, rotary		33
Centrifugal, miscellaneous		53
4 by 5 inch cylinder Novo engine		1
Power, No. 10 and parts		12
Centrifugal, boring		1
Centrifugal, Salmon		9
Hand		1,050
Steam, Black & Knowles		1
Steam, Cameron		2
Steam, Worthington		15
Steam, C. H. & E.		6
Steam, miscellaneous		7
Fairbanks & Morse, 8 by 4 by 10		32
Mine-sinking, and parts, Keystone		3
Mine-sinking, model D		8
Multistage type, Bovin & Co		1
Ranges, cook Nos. 1 and 2		694
Rods, level		34

Rollers:		
Steam		1
Road 5-ton Austin		7
Road 10-ton Austin		1
Scoops, Ally		12
Scrapers:		
Road		11
Sauerman, 1½-yard		1
Slip		105
Club Kibourne		21
Syracuse No. 1		12
4-wheel		14
Shovels, miscellaneous		7,684
Sledges, double, 8-pound		12
Steel:		
Bars, reforcing, 1¼-inch	pounds	420,790
Tool, hexagonal	do	36,050
Tables, folding		40
Tampers, concrete		6
Tanks:		
Galvanized-iron, 165-gallon		605
180-gallon		100
Tank, locomotive, 36-inch gauge		1
Tapes:		
Steel, miscellaneous		20
Steel, 100-foot		128
Steel, 50-foot		56
Metal, 25-foot		760
Metal, 50-foot		660
Metal, 100-foot		275
Tar pot on wheels		1
Tender, locomotive, 36-inch gauge and parts		14
Tents:		
Pyramidal, large		5,560
Pyramidal, small		150
Storage		107
Wall		124
Tires, auto		165
T. N. T	pounds	5,660,000
Tractors:		
Cleveland, 5-ton		6
Miscellaneous, 5-ton		16
Holt, 10-ton		6
Holt, 20-ton		299
Gas-driven, Titan, 15–30 horsepower		33
Gray, wide-drum		12
Holt, 75-horsepower		2
Holt, 15-ton		31
Trailers:		
3-ton platform		17
Searchlight		1
5-ton drop-frame		14
15-ton		2
Transits, engineers'		145
Trees:		
Single		16
Double		6
Trucks and warehouse cargo		12
Wagon:		
Dump, miscellaneous		207
Sprinkler, 450-gallon		194
Wheelbarrows		245

THE WADSWORTH-KAHN LAW.

A supplemental act of Congress was approved March 15, 1920. This act, known as Public No. 159—66th Congress, is merely more specific than section 7 of the Post Office appropriation act approved February 28, 1919, and reads as follows:

An act to authorize the Secretary of War to transfer certain surplus motor-propelled vehicles and motor equipment and road-making material to various services and departments of the Government, and for the use of the States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he is hereby, authorized and directed to transfer such motor-propelled vehicles and motor equipment, including spare parts, pertaining to the Military Establishment, as are or may hereafter be found to be surplus and no longer required for military purposes, to (*a*) the Department of Agriculture, for use in the improvement of highways and roads under the provisions of section 7 of the act approved February 28, 1919, entitled "An act making appropriations for the service of the Post Office Department, for the fiscal year 1920, and for other porposes:" *Provided, however,* That no more motor-propelled vehicles, motor equipment, and other war material, equipment, and supplies, the transfer of which is authorized in this act, shall be transferred to the Department of Agriculture for the purposes named in section 7 of said act than said Department of Agriculture shall certify can be efficiently used for such purposes within a reasonable time after such transfer; (*b*) the Post Office Department for use in the transmission of mails; and (*c*) the Treasury Department, for the use of the Public Health Service under the provision of section 3 of the act approved March 3, 1919, entitled "An act to authorize the Secretary of the Treasury to provide hospital and sanatorium facilities for discharged sick and disabled soldiers, sailors, and marines."

Sec. 2. That the Secretary of War is hereby authorized and directed to transfer to the Department of Agriculture, under the provisions of section 7 of the act approved February 28, 1919, entitled "An act making appropriations for the service of the Post Office Department for the fiscal year 1920, and for other purposes," for use in the improvement of highways and roads, as therein provided, the following war material, equipment, and supplies pertaining to the Military Establishment as are or may hereafter be found to be surplus and not required for military purposes, to wit, road rollers, graders, and oilers; sprinkling wagons; concrete mixers; derricks; pile-driver outfits complete; air and steam drill outfits; centrifugal and diaphragm pumps with power; rock crushers; clamshell and orange-peel buckets; road scarifiers; caterpillar and drag-line excavators; plows; cranse; trailers; rubber and steam hose; asphalt plants; steam shovels; dump wagons; hoisting engines; air-compressor outfits with power; boilers; drag, Fresno, and wheel scrapers; stump pullers; wheelbarrows; screening plants; wagon loaders; blasting machines; hoisting cable; air hose; corrugated-metal culverts; explosives and exploders; engineers' transits, levels, tapes, and similar supplies and equipment; drafting machines; planimeters; fabricated bridge materials; industrial railway equipment; conveyors, gravity and power; donkey engines; corrugated-metal roofing; steel and iron pipe; wagons and similar equipment and similar equipment and supplies such as are used directly for road-building purposes.

Sec. 3. That the Secretary of War is also hereby authorized and directed to transfer to the Department of Agriculture, for the use of the Forest Service, such telephone supplies pertaining to the Military Establishment which have been found to be surplus and no longer required for military purposes and are needed for the present use of the said service.

Sec. 4. That freight charges incurred in the transfer of the property provided for in this act shall not be defrayed by the War Department, and if the War Department shall load any of said property for shipment the expense of said loading shall be reimbursed the War Department by the department to which the property is transferred by an adjustment of the appropriations of the two departments: *Provided, however,* That any State receiving any of said property for use in the improvement of public highways shall, as to the property it receives, pay to the Department of Agriculture the amount of 20 per centum of the estimated value of said property, as fixed by the Secretary of Agriculture or under his direction, against which sum the said State may set off all freight charges paid by it on the shipment of said property, not to exceed, however, said 20 per centum.

SEC. 5. That the title to said vehicles and equipment shall be and remain vested in the State for use in the improvement of the public highways, and no such vehicles and equipment in serviceable condition shall be sold or the title to the same transferred to any individual, company, or corporation: *Provided*, That any State highway department to which is assigned motor-propelled vehicles and other equipment and supplies, transferred herein to the Department of Agriculture, may, in its discretion, arrange for the use of such vehicles and equipment, for the purpose of constructing or maintaining public highways, with any State agency or municipal corporation at a fair rental, which shall not be less than the cost of maintenance and repair of said vehicles and equipment.

SEC. 6. That the provisions of the act of July 16, 1914 (Thirty-eighth Statutes, page 454), prohibiting the expenditure of appropriations by any of the executive departments or other Government establishments for the maintenance, repair, or operation of motor-propelled or horse-drawn passenger-carrying vehicles in the absence of specific statutory authority, shall not apply to vehicles transferred, or hereafter to be transferred, by the Secretary of War to the Department of Agriculture for the use of the department under the provisions of this act, or under the provisions of section 7 of the act of February 28, 1919, referred to in section 1 hereof: *Provided, however*, That nothing in this act contained shall be held or construed to modify, amend, or repeal the provisions of the last proviso under the item entitled "Contingencies of the Army," as contained in the act entitled "An act making appropriations for the support of the Army for the fiscal year ending June 30, 1920, and for other purposes," approved July 11, 1919, except as to direction for the transfer of those articles enumerated in section 2 hereof.

Approved, March 15, 1920.

TRUCKS AND AUTOMOBILES.

Motor-propelled vehicles were made available by the War Department for transfer to the States in several installments. The first allotment of motor trucks totaled 5,333. This consisted of new trucks, and 5,210 had been delivered on April 1. The second allotment was 2,294 trucks. These were all used and nearly all serviceable, and a total of 1,188 of this allotment have been delivered. The third allotment consisted of 3,948 trucks, nearly all of which were new. Of this number 2,336 have been delivered, making a total of 8,734 motor trucks on the first three allotments that had been delivered to the States on April 1, 1920.

Since November 1, 1919, there have been taken over from the War Department 10,407 motor trucks. All of these have been allotted to the States and the great majority have been actually shipped. The total number of motor trucks transferred from the War Department for road-building purposes is 19,141. This figure will ultimately be decreased by a few rejections that have been made of trucks that have become unserviceable since their inspection by representatives of the Department of Agriculture.

The following is a statement showing the total number of trucks, Fords, and miscellaneous automobiles allotted to the various States and the totals received on April 1, 1920. The last column shows the percentage of total allotments received by each State. There have been but very few miscellaneous touring cars transferred to the State highway departments. It has been found that nearly all of the motor vehicles of this class were in such unserviceable condition that they would not warrant shipment to the State highway departments.

ALLOTMENTS AND DELIVERIES.

	Allotments.			Total vehicles allotted.	Total motor vehicles delivered to Apr. 1, 1920.	Percentage delivered.
	Trucks.	Fords.	Autos.			
1. Alabama	432	53	11	496	340	69
2. Arizona	282	35	6	323	277	86
3. Arkansas	343	42	8	393	326	83
4. California	622	77	15	714	579	81
5. Colorado	358	44	9	411	344	84
6. Connecticut	124	15	4	143	125	87
7. Delaware	34	4	4	42	42	100
8. Florida	236	29	6	271	200	74
9. Georgia	553	68	14	635	514	81
10. Idaho	251	31	6	288	230	80
11. Illinois	898	110	22	1,030	892	87
12. Indiana	556	68	14	638	505	79
13. Iowa	595	73	15	683	517	76
14. Kansas	593	73	15	681	538	79
15. Kentucky	400	49	10	459	368	80
16. Louisiana	280	34	7	321	287	89
17. Maine	196	24	5	225	182	81
18. Maryland	181	22	4	207	137	66
19. Massachusetts	303	37	7	347	208	60
20. Michigan	596	73	15	684	543	79
21. Minnesota	584	72	14	670	549	82
22. Mississippi	366	45	9	420	307	73
23. Missouri	697	86	17	800	614	77
24. Montana	413	50	10	473	370	78
25. Nebraska	440	54	11	505	387	77
26. Nevada	265	33	7	305	240	79
27. New Hampshire	83	11	2	96	88	92
28. New Jersey	245	30	10	285	273	96
29. New Mexico	331	40	8	379	315	83
30. New York	1,021	126	25	1,172	843	72
31. North Carolina	470	58	12	540	447	83
32. North Dakota	319	39	8	366	287	78
33. Ohio	761	94	19	874	762	87
34. Oklahoma	476	58	12	546	510	93
35. Oregon	326	40	8	374	295	79
36. Pennsylvania	942	116	23	1,081	776	72
37. Rhode Island	48	6	1	55	52	95
38. South Carolina	296	36	8	340	281	83
39. South Dakota	333	41	9	383	278	73
40. Tennessee	462	57	11	530	461	87
41. Texas	1,199	148	30	1,377	1,046	76
42. Utah	237	29	6	272	225	83
43. Vermont	95	12	3	110	85	77
44. Virginia	406	50	10	466	399	86
45. Washington	298	36	7	341	263	77
46. West Virginia	217	27	5	249	196	79
47. Wisconsin	521	64	13	598	399	67
48. Wyoming	252	31	7	290	232	80
49. Department of Agriculture	1,129	287	55	1,471	799	54
Total	21,065	2,737	557	24,359	18,933	78

THE TRUCKS DELIVERED.

The following is a list showing all of the motor trucks transferred from the War Department to the Department of Agriculture for distribution to the State highway departments. In this tabulation the trucks are arranged according to their makes and capacities.

	Number transferred.
Air Service [1]	1
Atterbury [1]	15
Commerce [1]	40
Denby [1]	10
Federal [1]	12
Garford [1]	114
G. M. C. [1]	10
Gramm-Bernstein [1]	37
Hurlburt [1]	58
Indiana [1]	4
International Harvester [1]	18
Kelly-Springfield [1]	72
Moreland [1]	27
Packard [1]	190
Peerless [1]	16
Pierce Arrow [1]	103
Republic [1]	20
Selden [1]	4
Standard [1]	37
Velie [1]	2
White [1]	6
Wilson [1]	1
	827
Ambulances:	
Garford	1
G. M. C.	281
Service	3
	285
¾-ton:	
Overland	4
Vim	1
	5
1-ton:	
Commerce	28
Denby	6
Federal	1
G. M. C	67
Moreland	4
Republic	8
	114
Light delivery:	
Buick	1
Maxwell	10
Oldsmobile	1
Reo	53
Stewart	1
	66
1¼-ton:	
Bethlehem	1
Kissel	2
	3
1½-ton:	
Atterbury	1
Auto Car	1
Brockway	9
Commerce	4
Dart	11
Denby	26
Diamond	1
Dort	2
Federal	2
G. M. C	81
International	7
Kelly-Springfield	67
Lip Stewart	1
Mack	1
Moreland	13
Packard	140
Pierce Arrow	7
Republic	9
Selden	1
Signal	1
Standard	9
Velie	14
Wilson	3
	411
Light aviation:	
G. M. C	65
Light aviation	425
	490
2-ton:	
Atterbury	5
Auto Car	7
Brockway	1
Dart	2
Denby	41
Diamond	1
Federal	40
Gramm Bernstein	2
International	314
Jeffery Quad	3
Kelly Springfield	9
Kissel	10
Mack	7
Master	3
Moreland	23
Nash Quad	6,489
Packard	6
Peerless	4
Pierce Arrow	873
Republic	12
Selden	42
Standard	34
Stewart	3
Union	1
Velie	20
Wilson	50
Winther	1
	8,003
2½-ton:	
Gramm-Bernstein	24
Moreland	21
Pierce Arrow	3
Sterling	4
	52
3-ton:	
Armleder	1
Atterbury	3
Denby	2
Diamond	10
Federal	235
Four-wheel drive	2,098
Gramm-Bernstein	29
Hurlburt	5
International	24
Kelly-Springfield	461
Masters	1
Moreland	47
Packard	1,818
Peerless	559
Pierce Arrow	233
Republic	129
Selden	17
Standard	76
Sterling	1
United Motor	1
Velie	115
White	48
Wilson	2
	5,915
3½-ton:	
Atterbury	1
Dart	1
Denby	1
Federal	35
Gramm Bernstein	11
Hurlburt	4
Kelly-Springfield	163
Packard	28
Republic	25
Selden	53
Service	2
Standard	145
Stewart	1
	470
Heavy aviation:	
G. M. C	74
Kelly-Springfield, heavy aviation	1,386
	1,460
4-ton:	
Moreland	21
Packard	63
Peerless	1
	85
5-ton:	
Denby	4
Federal	130
Garford	6
G. M. C.	4
Gramm-Bernstein	1
Hurlburt	48
Locomobile	1
Lombard	2
Packard	14
Pierce Arrow	697
Signal	1
Standard	2
White	32
	942
6-ton:	
Garford	10
Gramm-Bernstein	1
Locomobile	1
	12
8-ton:	
White	1

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[1] Capacity unknown.

RECAPITULATION.

Not designated	827
Ambulances	285
¾-ton	5
1-ton	114
Light delivery	66
1¼-ton	3
1½-ton	411
Light aviation	490
2-ton	8,003
2½-ton	52
3-ton	5,915
3½-ton	470
Heavy aviation	1,460
4-ton	85
5-ton	942
6-ton	12
8-ton	1
Total	19,141

THE REAVIS BILL.

There was omitted from the Wadsworth-Kahn bill by oversight a few items of equipment which the State highway departments have very much needed during the past year. A bill has been introduced in the House of Representatives recently by Mr. Reavis, known as H. R. 13329, to correct the omission from the bill approved March 15, 1920. This new bill provides for the transfer of 500 10-ton caterpillar tractors, complete, with spare parts; 200 mobile machine shop units, complete, with spare parts; shop machinery and machine tools and equipment suitable for repair shops and rebuilding shops for motor-propelled vehicles.

When this bill becomes a law it will make available several million dollars' worth of valuable shop tools and equipment needed by every State in the fitting out of their large rebuilding plants.

CATERPILLAR TRACTORS AVAILABLE.

An amendment was added to the Post Office appropriation act for the fiscal year ending June 30, 1921, which will make it possible for the State highway departments to secure 5 and 10-ton Holt caterpillar tractors from the War Department for road-building purposes. This law is known as section 29 of the Post Office appropriation act approved April 24, 1920, and reads as follows:

> That the Secretary of War be, and he is hereby, authorized and empowered, at his discretion, and under such rules and regulations as he may propose, to loan to any State of the Union, when so requested by the highway department of the State, five-ton and ten-ton Artillery tractors which are retained and not distributed under the act approved March 15, 1920, for use in highway construction by the highway department of such State: *Provided*, That all expenses for repairs and upkeep of tractors so loaned and the expenses of loading and freight shall be paid by the State, both in transfer to the State and the return to the Army.

It will be noted that this transfer of 5 and 10 ton Artillery tractors is to be made to the State highway departments directly by the Secretary of War. It will therefore be necessary for each State highway department to write direct to the Secretary of War should they desire to take advantage of this act.

SUBGRADE INVESTIGATIONS BEGUN BY BUREAU OF PUBLIC ROADS.

THE division of tests of the Bureau of Public Roads has begun investigations in the vicinity of Washington to obtain accurate scientific information regarding the characteristics of soils which affect their bearing value.

The problem of avoiding road failures of the kind which can be traced to poor foundations seems to be possible of solution in one of the following ways:

1. Make the road surface thick enough to distribute pressure over an area of subgrade sufficiently wide to reduce the intensity of pressure to a degree capable of support by the subgrade.
2. By increasing the thickness of the road surface add to its inertia sufficiently to absorb a considerable amount of the shock of traffic.
3. Design road slabs to have sufficient strength to bridge over the soft subgrade.
4. Improve drainage so as to exclude moisture in dangerous amounts from soils, the bearing value of which is seriously affected by the presence of moisture.

It is perhaps true that all soils have adequate bearing value when the amount of water in them is kept within certain low limits; or, it may be possible that certain soils can be treated in some way which will improve their natural bearing value.

It is obvious that if knowledge of road construction is to be advanced first attention must be given to the road foundation, and accurate information must be obtained as to the properties of soils which make them good or poor soils for foundation purposes.

The investigations which have been begun in the vicinity of Washington are designed to yield information of this character; and it is now planned to extend the scope of the investigation by obtaining the cooperation of the various State highway departments.

A memorandum has been sent to each of the 13 district engineers of the bureau, describing the character of the information it is desired to obtain. Each of the engineers is asked to secure the cooperation of State highway departments and State geologists in obtaining samples of soil from subgrades, underlying sections of road which have failed apparently because of poor drainage or peculiar soil condition.

The samples are to be 1 cubic foot in volume, and each is to be taken from the subgrade, preferably directly under the failure. Accompanying the sample the engineers are asked to supply photographs of the site of the failure and complete information in regard to the topography of the vicinity, the character of the failure, the approximate amount of traffic, drainage conditions, the presence of water-bearing strata, or other conditions which might contribute to the failure of the subgrade. Particular emphasis is placed upon the necessity of showing how the water reached the subgrade, whether by vertical capillarity, horizontal capillarity, through seepage strata, or from the surface.

It is suggested that a 1½-inch auger will be useful for exploring the underlying soil, and that much useful information may be obtained by noting the texture and moisture content of the soil at different depths. Thus, if the soil at the surface is wet, and below it is very compact, dense, and dry, it may be assumed as probable that the water has entered the subgrade from the surface, and has been prevented from escaping by the underlying impervious layer. If, on the other hand, the underlying layer of a wet subgrade is wet and porous, and it in turn is underlain by a compact impervious clay which is dry, it would seem that the porous layer is a seepage stratum through which the water flows and rises to the upper layers of the subgrade by vertical capillarity. A number of combinations are to be expected, and each must be carefully studied to determine how the water which exists in the subgrade at the time of failure arrived there.

It is believed that observations of a large number of failures together with samples of the soil underlying them, and similar observations and samples pertaining to sections of the same roads which have not failed, will furnish a clue as to the causes of such failures and lead eventually to the discovery of proper remedies.

The investigation is now in its preliminary stages, and the data which is asked for at this time is designed only to serve as the ground work for a very far-reaching investigation which will follow, in which it is hoped to enlist the cooperation of State university laboratories, organizations of engineers, and individuals throughout the country.

FEDERAL AID ALLOWANCES

PROJECT STATEMENTS APPROVED IN MARCH, 1920.

State.	Project No.	County.	Length in miles.	Type of construction.	Project statement approved.	Estimated cost.	Federal aid.
Alabama	69	Lamar	4.110	Gravel and earth	Mar. 2	[1] $53,231.31	[1] $26,615.65
Arkansas	69	Conway	6.020	Gravel	Mar. 3	59,771.80	12,500.00
	72	Lincoln	11.200	.....do	Mar. 19	27,270.98	7,040.00
	75	Dallas	21.750	.....do	...do	62,224.74	30,000.00
	76	.....do	14.290	.....do	...do	47,763.10	20,000.00
	83	Sevier	9.320	.....do	Mar. 26	37,206.12	18,600.00
	51	Conway	6.040	Bituminous surface	...do	107,708.70	49,156.00
California	50	Fresno	8.070	Concrete	Mar. 5	159,958.70	79,979.35
	48	Santa Clara	8.130	.....do	Mar. 10	190,330.80	95,165.40
	52	Mendocino	17.800	.....do	...do	454,821.40	227,410.70
	49	Santa Cruz	5.470	.....do	...do	135,663.00	67,831.50
	51	San Diego	6.670	.....do	...do	146,718.00	73,359.00
Colorado	15	Logan	.564	.....do	Mar. 3	19,945.20	9,972.60
	41	.....do		Bridges	Mar. 10	99,642.95	49,821.47
	83	Arapahoe	2.714	Concrete	Mar. 26	108,511.92	54,255.96
	109	Mesa	.977	.....do	Mar. 27	40,902.51	19,540.00
	35	Weld	1.228	Gravel	Mar. 26	49,364.61	24,560.00
	50	Elbert	16.880	Earth	Mar. 10	[2] 48,446.75	[2] 24,223.37
Georgia	110	Morgan	4.626	Concrete	Mar. 19	86,815.30	43,058.03
	125	Lee	14.000	Sand-clay	...do	91,026.24	20,000.00
Idaho	31	Benewah	10.900	Gravel	Mar. 3	197,806.40	98,903.20
	36	Franklin	21.800	.....do	Mar. 5	159,999.40	79,999.70
	34	Oneida	7.000	.....do	...do	49,997.20	24,998.60
	13	Bonneville	2.850	Concrete	Mar. 26	93,150.00	46,575.00
	22	.....do	3.000	.....do	Mar. 24	[2] 93,150.20	[2] 46,575.10
Indiana	20	Ripley	.977	.....do	Mar. 10	49,690.37	19,540.00
	21	Clark, Scott, and Jackson	44.700	Concrete, brick, or bituminous	Mar. 19	1,900,000.00	894,000.00
Iowa	114	Scott	17.230	Concrete or brick	Mar. 2	968,948.20	344,600.00
	117	Humboldt	10.830	Earth	...do	49,830.00	24,900.00
	102	North Liberty	18.200	.....do	Mar. 5	61,875.00	30,900.00
	132	Polk	29.200	Paved surface	Mar. 26	1,614,277.50	584,000.00
Kansas	46	Shawnee	9.480	Concrete, brick, or bituminous macadam	Mar. 2	577,775.00	142,200.00
	48	Jefferson	10.750	Brick, concrete, or bituminous macadam	...do	745,581.10	95,000.00
	49	Ottawa	5.500	Brick or concrete	Mar. 4	403,755.00	81,250.00
	50	Bourbon	.521	Bituminous macadam	Mar. 8	16,182.52	7,815.00
	42	Mead	5.000	Earth	Mar. 10	50,567.00	25,283.50
	51	Franklin	.830	Concrete or brick	Mar. 26	52,734.00	6,000.00
Kentucky	21	Bell	10.000	Bituminous macadam	Mar. 8	144,444.44	72,222.22
	23	Whitley	33.000	Water-bound macadam	Mar. 9	174,259.36	87,129.68
	24	Jessamine	3.000	Macadam	Mar. 19	35,222.00	17,611.00
	25	Washington	2.500	Macadam or bituminous surface	Mar. 26	49,912.50	24,956.25
	26	Jefferson	11.100	Macadam or asphalt	...do	432,342.53	216,171.26
Maine	6	Aroostook	5.870	Gravel	Mar. 5	79,585.00	39,792.50
	7	.....do	3.690	.....do	...do	49,720.00	24,860.00
	8	Waldo	2.540	Bituminous macadam	...do	118,094.90	59,047.45
	9	Cumberland	4.720	Concrete	...do	206,280.14	98,998.00
	10	.....do	2.520	Bituminous macadam	...do	107,870.67	50,400.00
	11	.....do	7.080	Concrete or bituminous macadam	...do	280,519.80	140,259.90
	12	.....do	6.640	.....do	...do	274,341.98	132,800.00
	13	Androscoggin	1.570	.....do	...do	67,135.75	31,400.00
	14	Penobscot	4.710	Bituminous macadam	...do	165,839.74	82,919.87
	15	.....do	7.440	.....do	...do	262,870.30	131,435.15
	16	.....do	4.080	.....do	...do	149,029.98	74,514.99
	17	Piscataquis	2.060	Gravel	...do	30,580.55	15,290.27
	20	Somerset	1.480	Bituminous macadam	...do	44,308.11	22,154.05
	21	.....do	6.440	.....do	...do	226,693.83	113,346.91
	26	Cumberland	3.920	.....do	...do	107,867.54	53,933.77
	27	.....do	8.640	.....do	...do	264,772.75	132,386.37
	33	Waldo		Bridge	...do	330,000.00	165,000.00
	19	Franklin	2.690	Gravel	Mar. 8	50,270.22	25,135.11
	18	.....do	3.938	.....do	Mar. 10	91,329.48	45,664.74
Maryland	38	Worcester	3.625	Concrete	Mar. 2	137,500.00	68,750.00
	39	Dorchester	2.350	.....do	Mar. 26	77,473.71	38,736.85
	32	St. Marys	[3] .400	Gravel	Mar. 8	[3] 40,817.70	[3] 20,408.85
	36	Anne Arundel	[3] 8.410	Concrete	Mar. 11	[3] 359,630.37	[3] 165,981.41
Minnesota	154	Morrison	9.410	Brick, concrete, or asphalt	Mar. 3	286,570.41	143,285.20
	137	Fillmore	6.250	Gravel	Mar. 4	24,750.00	12,375.00
	149	Aitkin	9.300	.....do	...do	48,004.00	24,002.00
	130	Big Stone	9.420	.....do	Mar. 5	81,686.00	40,843.00
	146	Lincoln	18.670	.....do	Mar. 8	105,166.60	52,583.30
	160	Otter Tail	11.400	.....do	Mar. 10	101,222.00	50,611.00
	142	Cass	7.930	.....do	Mar. 19	71,801.40	35,900.70
	147	Houston	21.800	.....do	Mar. 26	254,914.00	127,457.00
	96	Winona	4.610	Concrete, brick, or asphalt	...do	182,997.72	91,498.86
	159	Otter Tail	9.500	Gravel	...do	60,500.00	30,250.00
Mississippi	93	Pearl River	13.000	.....do	Mar. 2	110,041.80	55,020.90
	75	Chickasaw	5.810	.....do	Mar. 10	76,780.00	38,390.00
Missouri	90	Texas	28.310	.....do	Mar. 4	136,122.00	68,061.00
	91	Ripley	11.000	.....do	Mar. 5	50,373.40	25,186.70
Montana	75	Gallatin	2.000	.....do	Mar. 3	9,814.20	4,907.10
	77	Lewis and Clark	8.500	Gravel and concrete	...do	74,135.05	37,067.52
	82	Gallatin	6.500	Cement or bituminous concrete	...do	248,792.50	124,396.25
	89	Flathead	4.000	Gravel	Mar. 4	19,976.00	9,988.00
	76	Gallatin	5.800	.....do	Mar. 5	37,459.40	18,729.70
	86	Fallon	35.700	Sand-clay	...do	129,961.81	64,980.90
	91	Musselshell	1.350	Concrete	...do	60,154.60	27,000.00
	100	Flathead	4.500	Gravel	Mar. 10	17,902.50	8,951.25
	61	Wibaux	6.850	.....do	Mar. 19	32,041.46	16,020.73
	93	Flathead	3.500	.....do	...do	16,307.50	8,153.75
	79	Roosevelt		Bridge		15,400.00	7,700.00
	21	Missoula	7.000	Gravel	Mar. 11	[2] 21,995.60	[2] 10,997.80
	24	Blaine	5.000	.....do	Mar. 8	[2] 15,397.80	[2] 7,698.90
	38	.....do	6 000	.....do	...do	22,000.00	11,000.00

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[1] Revised statements. Amounts given are increases over those in the original statement.
[2] Withdrawn.
[3] Revised statements. Amounts given are decreases over those in the original statement.

PROJECT STATEMENTS APPROVED IN MARCH, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Nebraska	139	Madison, Antelope, and Holt.	62.600	Sand-clay or gravel	Mar. 2	$253,668.80	$126,834.40
	132	Holt, Garfield, and Wheeler.	74.800	Earth and sand-clay	Mar. 8	283,580.00	141,790.00
	135	Merrick	17.400	Gravel	Mar. 26	67,235.52	33,617.76
New Jersey	25	Atlantic and Burlington	2.253	do	Mar. 2	88,044.65	14,022.32
	26	Monmouth	6.380	Concrete	do	306,529.85	127,600.00
	20	Middlesex		Bridge		2,637,536.00	1,147,048.72
New Mexico	47	Grant	15.270	Gravel	Mar. 19	94,490.66	47,245.33
	48	Chaves	15.000	do	do	128,342.50	64,171.25
New York	47	Delaware	12.900	Concrete	do	516,000.00	258,000.00
North Carolina	114	Rowan	2.550	Bituminous	Mar. 2	92,927.89	46,463.94
	122	Durham	5.650	Concrete or bituminous macadam	do	219,762.18	109,881.09
	123	Craven	8.300	Concrete or hard surface	do	296,259.70	148,129.85
	116	Stanley and Montgomery		Bridge	Mar. 3	121,275.00	60,637.50
	127	Wilson	8.100	Sand-clay and gravel	Mar. 19	62,535.00	31,267.50
North Dakota	91	Emmons	10.500	Earth	Mar. 4	33,495.00	16,747.50
Ohio	113	Williams	1.187	Bituminous	Mar. 19	55,402.65	20,000.00
	112	Jackson	2.332	Concrete or bituminous surface	Mar. 26	125,000.00	42,500.00
	118	Wood	3.378	Concrete	do	157,400.00	20,000.00
	111	Delaware	7.420	Concrete or bituminous macadam	do	312,000.00	60,000.00
	114	Williams	2.580	Bituminous macadam	do	68,983.76	14,000.00
	136	Clermont	2.542	Water-bound or bituminous macadam	do	73,100.00	35,000.00
	138	do	4.820	do	do	154,700.00	70,000.00
Oklahoma	17	Grady		Bridge	Mar. 4	294,135.38	147,067.69
	20	Kay	17.278	Brick or concrete	Mar. 8	725,259.83	324,156.82
Oregon	37	Wasco	12.500	Earth	Mar. 9	265,113.75	132,556.87
	27	Columbia	10.850	Bitulithic	Mar. 26	252,466.50	126,233.25
	40	Wallowa	8.390	Earth	do	115,555.00	57,777.50
South Carolina	81	Charleston	7.384	Concrete	Mar. 3	321,524.94	102,000.00
	83	Union	7.074	Topsoil	Mar. 9	53,441.02	5,295.89
	67	Lee	18.114	Sand-clay	Mar. 19	257,035.60	21,750.00
South Dakota	46	Hamlin	15.750	Gravel	Mar. 2	107,701.00	53,850.50
	51	Gregory	16.000	Earth	do	69,289.00	34,644.50
	49	Lyman & Brule	8.950	Gravel	Mar. 10	77,518.10	38,759.05
Tennessee	27	Lewis and Lawrence	20.466	Earth	Mar. 19	88,282.92	44,141.46
	33	Crockett	5.666	Bituminous surface	do	133,669.58	66,834.79
Texas	136	Kaufman	35.060	Gravel	Mar. 2	505,002.30	138,000.00
	128	Montague	24.000	Gravel and sand-clay	Mar. 3	180,180.00	60,000.00
	129	Milam	8.769	Gravel	Mar. 19	68,368.13	25,000.00
	138	Limestone	11.917	Macadam	do	187,298.43	48,000.00
	140	Williamson	30.500	Gravel	Mar. 26	219,992.30	100,000.00
	122	Hill	[2] 17.000	do	Mar. 11	[2] 315,182.23	[2] 40,000.00
	49		[2] 13.700		Mar. 27	[2] 43,709.60	[2] 21,854.80
	123	Hill	[2] 12.820	Gravel	Mar. 11	[2] 145,370.70	[2] 25,000.00
Utah	29	Sanpete	11.400	Hard surface	Mar. 5	435,684.70	217,842.35
Vermont	13	Addison	4.070	Macadam or gravel	Mar. 19	122,173.92	61,086.96
Virginia	70	Campbell	4.300	Bituminous macadam	Mar. 2	110,000.00	55,000.00
	56	Tazewell	5.560	Gravel	Mar. 19	83,765.00	41,882.50
	67	Dickenson	5.927	Macadam	do	97,006.25	48,503.12
	81	Henrico	2.960	Bituminous	do	73,150.00	36,575.00
Washington	53	Stevens	5.990	Gravel	Mar. 3	87,044.10	40,000.00
	52	do	7.720	Gravel or crushed rock	Mar. 5	106,605.62	50,000.00
	51	Pierce	4.270	Concrete	Mar. 19	184,772.72	85,400.00
	55	Thurston	6.210	do	do	273,730.32	124,200.00
	57	do	1.990	do	do	70,915.62	35,457.81
	56	Walla Walla	3.410	do	do	143,125.97	68,200.00
	54	Grays Harbor	3.640	Earth	Mar. 26	52,862.04	26,431.02
West Virginia	85	Roane	3.000	Concrete	Mar. 8	67,200.00	27,200.00
	86	Mingo	3.020	Earth	Mar. 19	52,580.00	21,600.00
	90	Wood	2.000	Concrete	do	70,400.00	32,001.00
	87	Mason	4.500	Gravel	Mar. 26	58,850.00	28,520.00
	88	Wayne	2.800	Earth	do	47,300.00	23,650.00
Wisconsin	115	Walworth	4.720	Concrete	Mar. 2	196,965.32	77,465.00
	140	Iowa	8.270	Earth	do	65,103.04	25,000.00
	154	Fond du Lac and Milwaukee.	3.590	Concrete	Mar. 3	122,145.71	46,650.00
	137	Fayette	1.530	Earth	Mar. 5	27,486.29	10,000.00
	157	Green Lake	.610	Concrete	do	20,013.14	7,434.34
	116	Winnebago	6.270	do	Mar. 10	207,000.00	70,500.00
	129	Marinette	7.820	Earth	do	75,479.75	26,000.00
	139	Brown	2.910	Concrete	do	98,174.89	30,000.00
	150	Dodge	6.450	do	do	262,867.55	87,622.51
	145	Clark	3.700	Macadam	Mar. 19	35,692.25	11,000.00
	164	La Crosse	2.090	Concrete	do	98,999.05	34,500.00
	155	Forest	3.180	Gravel	do	30,000.00	10,500.00
	147	Clark	5.580	do	Mar. 26	44,607.36	15,200.00
	61	Sauk	.760	do	do	23,657.62	9,000.00
	122	Pierce	10.400	do	do	100,068.45	36,268.00
	76	Portage	[2] 6.370	do	Mar. 27	[2] 31,019.23	[2] 10,359.71
Wyoming	68	Hot Springs	4.281	Selected material	Mar. 2	52,360.00	26,180.00
	50	Lincoln	2.639	Gravel	Mar. 19	25,300.00	12,650.00
	70	Washakie	2.902	Selected material	Mar. 26	26,290.00	13,145.00
	71	do	3.125	do	do	22,440.00	11,220.00

PROJECT AGREEMENTS EXECUTED IN MARCH, 1920.

Alabama	70	Barbour	3.010	Sand-clay	Mar. 4	$27,552.53	$13,776.26
	64	Pike	13.970	Sand-clay and gravel	Mar. 26	115,535.25	57,767.62
	56	Jefferson		Bituminous concrete	do	[1] 19,240.07	[1] 9,620.03
Arizona	17	Yavapai	5.000	Broken stone	Mar. 22	210,347.26	100,000.00
	1	Pinal		Reinforced concrete or brick	do	7,778.50	3,889.25
Arkansas	58	Hempstead	5.020	Gravel	Mar. 26	34,897.98	12,000.00
	32	do		do	Mar. 11		[1] 12,000.00
Colorado	28	Summit	2.093	Earth	Mar. 17	34,994.42	17,497.21
	31	Adams and Arapahoe	1.161	Concrete	do	43,603.64	21,801.82
	29	Jefferson	1.946	Earth	do	59,751.58	29,875.79

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[1] Modified agreements. Amounts given are increases over those in the original agreement.

[2] Withdrawn.

PROJECT AGREEMENTS EXECUTED IN MARCH, 1920—Continued.

State.	Project No.	County.	Length in miles.	Type of construction.	Project agreement signed.	Estimated cost.	Federal aid.
Georgia	82	Lumpkin	7.960	Gravel or crushed stone	Mar. 4	$77,441.25	$38,720.62
	23	Forsythe	11.309	Topsoil	...do...	63,723.45	25,000.00
	74	Sumter		Bridge	...do...	39,456.08	15,000.00
	96	Floyd	7.248	Bituminous macadam	...do...	101,406.25	50,000.00
	97	Troup	5.130	Topsoil	...do...	61,359.06	26,668.15
	54	Floyd	2.848	Bituminous concrete	Mar. 20	101,126.69	50,563.34
	77	Charlton	19.240	Gravel	Mar. 24	276,944.23	138,472.11
	103	Chatham	3.306	Concrete	Mar. 6	111,736.15	50,000.00
	101	Sumter	3.000	Bituminous macadam	Mar. 20	79,968.17	39,984.08
	35	Whitfield	5.834	Chert	Mar. 13	52,069.80	26,034.90
	64	Glynn	4.370	....do	Mar. 19	103,728.70	51,864.35
	24	Cherokee	.997	Topsoil road	...do...	[2] 11,159.23	[2] 5,657.54
Illinois	1-22, 21	Kane, Dupage	2.821	Concrete	Mar. 4	80,367.26	40,183.62
	5 F	Peoria	.587	....do	...do...	23,415.21	11,707.60
	1, 1-5, 8-18		1.304	....do	...do...	[1] 34,834.75	[1] 17,417.38
Kansas	27 I	Reno	.214	....do	...do...	7,104.46	3,210.00
	27 A, B, C, D, E, F, G	....do	34.964	Brick	...do...	2,137,332.00	524,460.00
	30 B	Lyon	4.489	....do	Mar. 5	203,212.17	67,335.00
	41	Atchison	8.572	Concrete or brick	Mar. 26	553,860.67	128,580.00
Kentucky	7 A-B	Hart	3.285	Macadam	Mar. 13	68,007.72	34,003.86
	10 A	Larue	2.974	....do	...do...	63,999.94	31,999.97
Maryland	36	Anne Arundel	.590	Concrete	Mar. 21	36,369.63	14,018.59
Minnesota	111	Redwood	1.970	Gravel	Mar. 2	8,274.47	4,000.00
	13	....do		Earth	Mar. 26	[1] 51,648.41	[1] 28,000.00
	38	Mower		Gravel	Mar. 5	[1] 50,298.15	[1] 30,000.00
Mississippi	21	Lowndes	7.320	....do	Mar. 4	53,160.47	26,580.23
	17	Holmes	3.710	....do	Mar. 3	24,236.63	12,118.31
	28	Lowndes	5.364	....do	Mar. 19	76,489.32	38,244.66
	9	Kemper			Mar. 3	[2] 9,960.50	[2] 4,980.25
Missouri	31	Washington	3.530	Gravel	Mar. 9	14,405.09	7,202.54
	22	Randolph	1.660	Brick or concrete	...do...	56,086.71	28,043.35
	6	Clay	10.520	Bituminous macadam	Mar. 20	274,443.01	68,610.75
	19	Jackson	2.390	Concrete or asphalt concrete	Mar. 26	115,906.18	47,800.00
	25	Clay	13.050	Bituminous macadam	...do...	355,716.90	177,858.45
Montana	54	Cascade	.860	Gravel	...do...	5,855.30	2,927.65
Nebraska	60 A	Howard	7.580	Earth and sand-clay	Mar. 3	53,151.68	26,575.84
	52	Phelps	9.979	Clay-gravel	Mar. 22	45,462.43	22,731.21
	66	Cherry	24.560	Sand-clay	...do...	227,505.33	113,752.66
	22	Custer	31.870	....do	Mar. 30	201,960.90	100,980.45
New Hampshire	32	Rockingham	1.290	Gravel, surface-treated	Mar. 3	10,066.95	5,033.47
	52	Sullivan	1.060	Gravel	...do...	14,790.00	7,395.00
	59	Cheshire	.870	Water-bound macadam	...do...	18,995.18	9,497.59
New Mexico	1 B	Colfax	14.370	Gravel	Mar. 5	157,492.41	78,746.20
	46	Santa Fe	.572	....do	Mar. 13	10,326.59	5,163.29
	19	Luna	11.676	....do	Mar. 26	85,399.20	42,699.60
New York	12	Cortland	6.540	Reinforced concrete	...do...	261,600.00	130,800.00
	5	Columbia		Concrete	...do...	[3] 18,945.40	[3] 9,472.70
North Carolina	74 A	Stanley	2.083	Topsoil	Mar. 6	23,390.30	11,695.15
	85	Davie	8.280	....do	...do...	45,188.39	22,594.19
	48 A	Northampton	5.804	Gravel on sand-clay base	Mar. 9	58,814.38	29,407.19
	46	Beaufort	.720	Concrete	Mar. 31	27,450.26	13,725.13
	52	Cabarrus	8.986	Topsoil	...do...	130,960.19	65,480.09
	56	Forsyth	5.868	Topsoil or gravel	...do...	62,054.85	31,027.43
	99	Chatham	12.650	Topsoil	...do...	94,269.56	47,134.78
	22	Alamance	.760	Concrete and bituminous macadam	...do...	[1] 246,023.92	[1] 132,589.68
	17	Wilkes		Earth road	Mar. 19		[1] 25,000.00
	12	Wayne	.390	Sand-clay gravel	Mar. 26	[1] 27,294.53	[1] 5,000.00
Ohio	98	Jefferson	2.327	Brick	Mar. 4	114,000.00	46,540.00
	87	Champaign	5.068	Brick or reinforced concrete	Mar. 13	205,200.00	50,700.00
	90	Jackson	2.478	Bituminous macadam	Mar. 10	43,000.00	20,000.00
	81	Pickaway	4.092	....do	Mar. 18	100,000.00	50,000.00
Oklahoma	4	Comanche	.020	Concrete	Mar. 26	[1] 20,185.80	[1] 10,092.90
Oregon	19	Marion	4.160	Asphalt concrete	Mar. 2	112,931.06	56,465.53
	23	Lake	1.780	Gravel	Mar. 3	9,334.05	4,667.02
	38	Umatilla	7.540	....do	Mar. 9	107,926.98	53,963.49
	6	Wheeler and Grant	49.250	Earth	Mar. 19	728,136.60	364,068.30
	7	Marion		Bituminous concrete	Mar. 3	[1] 28,151.75	[1] 31,397.72
South Carolina	46	Kershaw	2.130	Gravel	Mar. 20	23,208.99	11,604.49
	47	Florence	5.982	Concrete	Mar. 15	220,282.68	84,900.54
	7	Horry		Sand-clay	Mar. 5	[1] 39,327.70	[1] 19,663.85
South Dakota	23	Jackson and Washabaugh		Bridge	Mar. 13	28,029.47	14,014.73
	27	Lyman and Tripp		....do	Mar. 30	36,875.03	18,437.51
Tennessee	12	Union-Claiborne	13.639	Macadam	Mar. 5	296,860.42	148,430.21
	13	Carroll	2.791	Chert	Mar. 17	35,939.82	17,969.91
Texas	37	Fayette	11.270	Gravel	Mar. 8	144,827.27	61,773.00
	15	Wharton	5.900	....do	Mar. 5	97,623.15	20,250.00
	110	McLennan	1.010	Concrete	Mar. 20	41,777.54	20,200.00
	61	Wichita		Bituminous-treated gravel	Mar. 22	[1] 111,047.99	[1] 25,741.25
	3	....do		....do	Mar. 23	[1] 344,901.43	[1] 18,800.36
Virginia	45	Henry	4.469	Topsoil	Mar. 12	74,194.67	37,097.33
	54	Rockbridge	2.059	Water-bound macadam	...do...	44,084.59	22,042.29
West Virginia	57	Cabell	1.000	Brick	Mar. 13	42,101.48	19,200.00
	72	Hampshire	.500	Earth	...do...	6,300.00	3,150.00
	29	Ritchie		Concrete	Mar. 5		[1] 31,360.00
	56	Jackson	.330	....do	Mar. 13	15,500.00	6,500.00
Wisconsin	34	Iowa		Earth	Mar. 1	[1] 3,414.94	[1] 1,138.31
Wyoming	25	Crook	19.580	Gravel	Feb. 28	171,479.77	85,739.88
	32	Fremont		Bridges	...do...	45,815.79	22,907.89
	33	Albany	2.158	Water-bound macadam	...do...	30,464.43	15,232.21
	17	Uinta	3.832	Sand-clay	Mar. 13	21,423.98	10,711.99
	36	Albany	14.928	Gravel	...do...	36,593.20	15,296.60
	39	Big Horn	8.161	....do	...do...	69,950.43	34,975.21
	47	Fremont		Bridge	...do...	13,712.51	6,856.25

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[2] Revised agreements. Increase.
[3] Modified agreement. Amounts given are decreases over those in the original agreement.

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DATE DUE

DEMCO, INC. 38-2931